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Geodatabase Design for FEMA Flood Hazard Studies

by

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> "So why do you call me `Lord,' when you won't obey me? I will show you what it's like when someone comes to me, listens to my teaching, and then obeys me. It is like a person who builds a house on a strong foundation laid upon the underlying rock. When the floodwaters rise and break against the house, it stands firm because it is well built. But anyone who listens and doesn't obey is like a person who builds a house without a foundation. When the floods sweep down against that house, it will crumble into a heap of ruins." Luke 6:46-49 (NLT)

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Abstract

Geodatabase Design
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The University of Texas at Austin, 2006

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As a part of its Map Modernization Program, the Federal Emergency Management Agency (FEMA) specifies in the *Guidelines and Specifications for Flood Hazard Mapping Partners* how Flood Hazard Mapping Partners will submit geographic information system (GIS) data through the Digital Flood Insurance Rate Map (DFIRM) database (specified in Appendix L) and the Data Capture Standards (DCS) database (specified in Appendix N). This thesis describes the design of a FEMA Flood Study Geodatabase (FSG) and involves: (1) merging the DFIRM database with the DCS database and removing overlapping tables; (2) converting the DFIRM/DCS relational database system into a Geodatabase (i.e., the FSG); (3) developing a correlation between the FSG and the Arc Hydro data model; (4) developing an XML version of the FSG schema; and (5) relating the flood hazard data to the National Hydrography Dataset (NHD). The critique and recommendations contained herein are offered with the intent to improve the utility of FEMA's multi-billion dollar investment in flood hazard data.

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List of Abbreviations

BFE	Base Flood Elevation
BRWMC	Bexar Regional Watershed Management Coalition
CADD	Computer Assisted Drafting and Design
CAPCO	Capital Area Council of Governments (Texas)
CRWR	Center for Research in Water Resources
CUAHSI	Consortium of Universities for the Advancement of Hydrologic Science, Incorporated
DCS	Data Capture Standards (Appendix N)
DEM	Digital Elevation Model
DFIRM	Digital Flood Insurance Rate Map (Appendix L)
DHS	Department of Homeland Security
DTM	Digital Terrain Model
EPA	Environmental Protection Agency
ESRI®	Environmental Systems Research Institute, Inc.
FEMA	Federal Emergency Management Agency
FHMP	Flood Hazard Mapping Partner of the FEMA Map-Mod Program
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
FMP	Flood Map Project
FSG	Flood Study Geodatabase
GIS	Geographic Information System
HEC	Hydrologic Engineering Center
HSPF	Hydrological Simulation Program – FORTRAN

HSMM	Hayes, Seay, Mattern & Mattern, Inc.
HTML	Hypertext Modeling Language
HUC	Hydrologic Unit Code
HWM	High Water Mark
LCRA	Lower Colorado River Authority
MIP	Mapping Information Platform (FEMA Map Modernization Program)
NFIP	National Flood Insurance Program
NGS	National Geodetic Survey
NHD	National Hydrography Dataset
NSP	National Service Provider (FEMA Map Modernization Program)
RDBMS	Relational Database Management System
RWMS	Regional Water Management System
SARA	San Antonio River Authority
TBM	Temporary Benchmark
TMDL	Total Maximum Daily Load
TSDN	Technical Support Data Notebook
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
VBA	Microsoft Visual Basic for Applications
WISE®	Watershed Information SystEm
XML	Extensible Markup Language

An extensive list of abbreviations used in the FEMA Flood Hazard Mapping Program is presented in the *Acronyms and Abbreviations* reference of the *Guidelines and Specifications for Flood Hazard Mapping Partners* (FEMA, 2003, Acronyms and Abbreviations).

Chapter 1 Introduction

From the world's earliest records, water has played an integral role in civic development. Water is viewed both as an invaluable resource to be protected and a violent force to be respected. The evolution of water as a precious resource continues today; we are also developing better practices for mitigating losses from water in its destructive capacity - flooding. With the continually-growing population of the United States, it is certain that without proper guidance, a large number of homes will be built in areas that place them at the mercy of flood events. Recent natural disasters such as Hurricanes Katrina and Rita (illustrated in Figure 1.1) have demonstrated that flood management is a relevant and significant topic.

Figure 1.1 New Orleans Flooding from Hurricane Katrina (2005)

1.2 Background

The Federal Emergency Management Agency (FEMA) is a national agency responsible for managing the mitigation of losses due to disaster events. Their mission is:

> …to reduce loss of life and property and protect our Nation's critical infrastructure from all types of hazards through a comprehensive, risk-based, emergency management program of mitigation, preparedness, response, and recovery.
> (FEMA, 2003, Executive Summary, p. vi)

To that end, the U.S. Congress delegated to FEMA the authority to create and update national flood hazard information on a local scale according to the National Flood Insurance Act of 1968 in support of the National Flood Insurance Program (NFIP). The goal of the NFIP is to collect flood insurance fees from those individuals who live in regions subject to a higher risk of flooding, because there is an estimated $650 billion of insured assets in the NFIP. In order to properly assess these fees, it is necessary to identify geographic regions of higher flooding risk. Thus, FEMA has a continuous program to (1) develop new Flood Insurance Rate Maps (FIRMs) for regions lacking maps, and (2) to update effective FIRMs (current maps).

1.3 Map Modernization Program

In the late 1990's, FEMA administrators realized that the NFIP program was financially over-extended and that the majority of the effective FIRMs were obsolete.

> To provide a sound basis for floodplain management and insurance rating, the Flood Hazard Maps must present flood hazard information that is accurate and up to date. However, funding levels for flood hazard mapping have not been sufficient for FEMA to update the entire inventory of Flood Hazard Maps. As a result, nearly 75 percent of the Flood Hazard Map panel inventory is over 10 years old.
> (FEMA, 2003, Executive Summary, p. ii)

Indeed, many of the FIRMs had not been updated since their original study. Thus, the U.S. Congress appropriated a large financial contribution (projected to be $200 million per year from 2003 to 2008) to fund the Map Modernization Program, which was initiated to restudy the existing FIRMs for the entire United States and create new FIRMs where necessary. For this program, FEMA developed the *Guidelines and Specifications for Flood Hazard Mapping Partners* to outline the FIRM creation process.

1.3.1 FIRM Creation Process (adapted from FEMA, 2003, Volume I)

FEMA's objectives to develop and update FIRMs are fulfilled in five phases illustrated in Figure 1.2 (adapted from FEMA, 2003, Volume 1, Figure 1-1, p. 1-4):

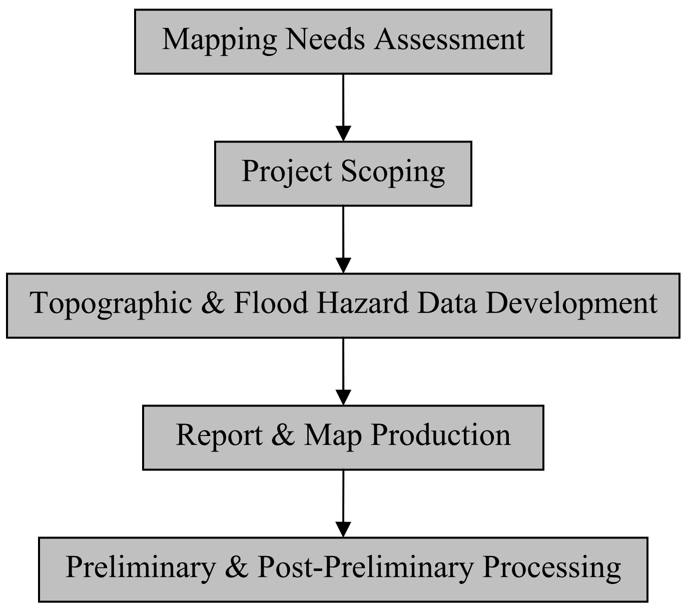


Figure 1.2 Flood Hazard Mapping Process Flowchart

The objective of the Mapping Needs Assessment phase is to evaluate whether the flood hazard data and other data shown on FIRMs are adequate for communities with flood hazard data. For communities without effective FIRMs, the purpose of the Mapping Needs Assessment is to determine whether the community is flood prone and whether a FIRM should be produced. While it may be more financially and chronologically efficient to perform flood hazard studies by Hydrologic Unit Code (HUC) SubRegion, the vast majority of Flood Mapping Projects are contracted on a countywide basis, which provides a simple means of financial accountability through the existing local political structure. Thus, the Flood Hazard Mapping Partners meet with representatives from the county, cities, and communities impacted by the project.

The Project Scoping phase begins after a community's mapping needs have been identified and FEMA and the community have decided to initiate a Flood Map Project (FMP) to create or update a FIRM. This scoping phase includes tasks such as:

- Conduct community outreach
- Determine what existing flood hazard data can be used without revision (redelineation)
- Identify other necessary data to complete the FMP
- Establish priorities for the analysis and mapping of flood sources
- Define the level of detail of each analysis (approximate, enhanced approximate, or detailed)
- Develop schedules and cost estimates
- Assign project tasks to Flood Hazard Mapping Partners (those performing the analyses)

The Topographic and Flood Hazard Data Development Phase includes tasks of:

- Developing and obtaining topographic data
- Surveying structures and cross-sections
- Hydrologic modeling (estimating runoff)
- Hydraulic modeling (calculating flood water surface elevation)
- Floodplain boundary delineation

The Report and Mapping Production Phase includes the following tasks:

- Preparing the base map for FIRM production
- Digitizing effective FIRM data that does not require revision
- Producing the Flood Insurance Study (FIS) report and Flood Profiles

The Preliminary and Post-Preliminary phase is a review period to invite comments from the community on the "Preliminary" maps through public hearings and distribution to community officials. If significant changes are made, the maps are reviewed again as "Revised Preliminary." When required, FEMA initiates a statutory 90-day appeal period to provide community officials and citizens a formal opportunity to appeal any new or modified Base Flood Elevations (BFEs). The following tasks occur during the remainder of the post-Preliminary process:

- Compliance period (usually 6 months)
- Quality assurance and quality control (QA/QC) reviews to ensure accuracy of the FIRMs
- Printing by the US Government Printing Office (GPO) in coordination with the FEMA Map Service Center (MSC)
- Printing and distributing the FIRM and FIS report

1.3.2 Flood Study Types

There are five methods of flood hazard boundary creation in the Map Modernization Program: approximate study, enhanced approximate study, detailed study, redelineation, and digital conversion. These five flood hazard study methods are summarized in Table 1.1.

Table 1.2 Five Methods of Flood Hazard Mapping

Hazard Study Method	Estimated Cost per Stream Mile	Description
Approximate	\$150 - \$1000	Least expensive new study method: no structures, only 1% flood boundaries
Enhanced Approximate	\$500 - \$2500	More thorough than approximate study: includes approximate survey structures
Detailed	\$5000 - \$10,000	Most thorough study: includes detailed survey structures, BFEs, floodways, and flood boundaries of the 1% and 0.2% events.
Redelineation of Existing	\$500 - \$1000	Extract water surface details (only from previous detailed studies) from BFEs and cross-sections and project onto new terrain model to delineate new flood hazard boundaries.
Digital Conversion of Existing	\$750 - \$1000	In the absence of data, simply digitize previous map details

An approximate study involves the least amount of information for new studies and is performed in areas with sparse population and development. Approximate studies generally include medium to low resolution terrain data (30 m and 10 m DEMs, USGS Quad contours, etc.) and regression equations to determine riverine flow values. Reach geometries are created by taking cross-section and stream profiles from the terrain data (topographic cross-sections and stream profiles). Approximate hydraulic modeling usually assumes a conservative, constant value describing channel roughness (Manning's n) for the entire reach. Approximate flood hazard studies only include floodplain boundaries of the one percent flood event.

The enhanced approximate study improves upon the approximate study by adding information about major structures along the reach. For instance, basic structure dimensions such as height, width, length, number of barrels, barrel dimensions, and number of piers are recorded for bridges. This survey system enables the engineer to add "approximate structures" to the hydraulic model to improve the accuracy of the hydraulic conveyance system without incurring the cost of complete detailed surveys.

The detailed study is the most comprehensive study and the most costly to perform. Detailed studies generally involve medium to high resolution terrain data (LIDAR, IFSAR, aerial photogrammetry for Mass Points and Breaklines, etc), and hydrologic models usually include land use and land cover data in rainfall-runoff models. Hydraulic models include an upstream, top-of-road, and downstream surveyed cross-sections of structures or a surveyed cross-section of the stream profile for every stream mile. Hydraulic models are also improved by determining channel and riparian zone roughness from orthophotographs. Maps produced from detailed studies include floodplain boundaries, floodway boundaries, and base flood elevation (BFE) lines. In addition to the map details, stream profiles are included in the FIS report.

Redelineations only involve the projection of effective (pre-existing) detailed study map elements (floodplain boundaries, Base Flood Elevations (BFEs), floodway marks, etc.) onto new terrain data. Similarly, the digital conversion method is used when there is insufficient data to perform a redelineation, and the effective map elements are simply digitized and included in the new FIRM with no engineering analyses.

1.3.3 Flood Study GIS Archival

One of the main goals of the Map Modernization program is to develop Digital Flood Insurance Rate Maps (DFIRM) in place of the existing paper FIRMs. This digital archival provides certain advantages over paper (hard-copy) archival:

> Preparing these data in digital format has significant advantages. Digital data allow for more efficient storage, update, records search and distribution. The most significant advantage is that the data are designed to work within a GIS environment. This means that the FEMA database can be used for automated analyses that are costly and impractical with paper products and is compatible with Internet applications. (FEMA, 2003, Appendix L, p. L-16)

A geographic information system (GIS) is a database that records the geometry of geographically positioned features and attributes about those features. For example, Google™ Maps (http://maps.google.com/) uses a GIS that contains national road networks, streams and lakes, aerial photography, political boundaries, and business locations in a common, geographically-referenced framework that can be used to perform analyses (e.g., shortest path travel directions, nearest business, etc.).

Desiring to create a GIS for the Map Modernization Program, FEMA developed the DFIRM database specified in *Appendix L* of the *Guidelines and Specifications for Flood Hazard Mapping Partners*, which records geometries and associated tabular attributes of the mapping elements in a FIRM. The DFIRM database also allows Flood Hazard Mapping Partners to voluntarily submit data from the engineering studies performed to develop a DFIRM, but this voluntary portion of the DFIRM database has been ignored by most of the Flood Hazard Mapping Partners.

After the Map Modernization program was underway, the FEMA Map Modernization administrators realized that the Flood Hazard Mapping Partners were not going to submit the supporting engineering data unless obligated. Moreover, the administrators also realized that the DFIRM database was not well suited to store this engineering data, so they developed the Data Capture Standards (DCS) database specified in Appendix N of the Guidelines and Specifications for Flood Hazard Mapping Partners, which records geometries and attributes of supporting engineering data used in the analyses performed in the development of a DFIRM.

1.4 Motivation and Objective

Soon after FEMA developed the Data Capture Standards (DCS), the FEMA regional administrators realized the complexity of requiring Flood Hazard Mapping Partners to submit data according to two separate databases. Most of the complication of this dual-database system results from the inconsistencies in the seemingly overlapping portions of the DFIRM and DCS databases. Moreover, the current DFIRM and DCS databases form a rudimentary GIS that is tedious to manage and update.

Federal agencies are instructed to promote interoperability and offer benefits from their data development to a larger, more generic, interest group. Considering the national scope of the Map Modernization Program and the level of detail of the studies involved, there are many other scientific or public communities related to water resources that could benefit from the vast resources compiled in the Map Modernization Program.

Thus, the objective of this research project is to design a Flood Study Geodatabase (FSG) that merges the DFIRM and DCS databases and can be related to the more generic water resources community.

1.5 Document Outline

This thesis is divided into seven chapters. The first chapter provides an introduction to the flood hazard mapping context of this research project, and the second chapter provides a review of the FEMA guidelines that specify the current GIS archival database structures. The third chapter describes several technologies relevant to flood hazard mapping. The fourth chapter outlines the intellectual framework and underlying principles affecting the design of the Flood Study Geodatabase (FSG) and a summary of the resulting schema (structure). The fifth chapter describes the technological methods used in developing the Flood Study Geodatabase, and the sixth chapter presents a case study of Flood Study Geodatabase data for Fayette County, Texas. The seventh chapter ends the report with conclusions from the geodatabase design project. Three appendices are included: (A) a Visual Basic for Applications (VBA) script used to create an XML file of the Flood Study Geodatabase schema from an Excel spreadsheet; (B) a geodatabase diagram of the Flood Study Geodatabase structure; and (C) a set of attribute tables describing the Flood Study Geodatabase schema.

Chapter 2 Literature Review

The two principle documents relevant to the design of a geodatabase for FEMA flood hazard mapping are (1) *Appendix L of the Guidelines and Specifications for Flood Hazard Mapping Partners: Guidance for Preparing Draft Digital Data and DFIRM Database* (FEMA, 2003, Appendix L) and (2) *Appendix N of the Guidelines and Specifications for Flood Hazard Mapping Partners: Data Capture Standards* (FEMA, 2005, Appendix N). These standards specify the current GIS databases used for archiving flood hazard models and results.

2.1 APPENDIX L – DIGITAL FLOOD INSURANCE RATE MAP (DFIRM)

Appendix L was written in 2001 and originally published in February 2002. Modifications to the original document were published in April 2003.

2.1.1 Purpose and Document Organization

As part of the Map Modernization program, FEMA specifies the manner in which Flood Hazard Mapping Partners are to submit Digital Flood Insurance Rate Map (DFIRM) data in *Appendix L* of the *Guidelines and Specifications for Flood Hazard Mapping Partners* (FEMA, 2003, Appendix L). Data contained within the DFIRM database are the "output and deliverables," which are essentially the map details displayed on the DFIRMs and other project metadata. Several DFIRM design decisions are recorded in the introductory section of Appendix L:

> Where possible, all mapping and engineering data elements will be linked to physical geographic features that are georeferenced. A GIS has the ability to precisely overlay the mapping and engineering data. This approach supports a wide variety of existing and visionary FEMA engineering and mapping products, such as digital mapping; automated hydrologic and hydraulic modeling, automated mapping, web-based publishing, and direct links between modeling and mapping elements.

> The DFIRM database is not intended to be used to produce an exact replica of the printed Flood Insurance Rate Map (FIRM). Instead, the DFIRM database is designed to allow a GIS user access to all of the information conveyed on the FIRM in a way that can best take advantage of the automated analysis capabilities of GIS. FEMA will provide a companion product in the form of a scanned or raster image of the hardcopy DFIRM that will allow users to reprint exact replicas of the whole FIRM or portions of the FIRM.
>
> The DFIRM database will be designed to be usable in a standard Relational Database Management System (RDBMS), but will be software independent. Therefore, the products are defined as flat tables in public domain formats (e.g., ESRI Shapefiles, MapInfo MIF files). Users can import these formats into a wide variety of software packages. These file formats manage GIS data in discrete files, generally organized by data theme. As a result, they do not support the inter-table relationships and data integrity enforcement capabilities of an RDBMS. However, the data produced by FEMA will be designed, tested to follow these rules, and fully compatible with an RDBMS.
> (FEMA, 2003, Appendix L, p. L-22)

Appendix L is organized into four main sections: (1) an overview of the DFIRM database system, (2) a description of Draft Digital Data, (3) a description of Preliminary/Final DFIRM databases, and (4) a listing of the attribute tables that specify the field parameters of each table in the database. The Draft and the Preliminary/Final versions are essentially different versions of the same DFIRM database; that is, the Draft Digital Database is specified to be used *during* the study process, whereas the Preliminary/Final DFIRM database is to be submitted when receiving Preliminary or Final status. Perhaps the two most critical distinctions between the Draft version and the Preliminary/Final version are that (1) the Draft version allows more flexibility in submittal formats (*e.g.*, Mapping Partners are allowed to submit attributes in spatial files in CADD format and the associated attribute tables in a spreadsheet as opposed to the preferred shapefile and database combination), and (2) the Draft version employs domain tables (an additional table that restricts the valid entries of a field within an attribute table).

2.1.2 DFIRM Database Structure

Each table within the DFIRM database is described by two characteristics: (1) "Required" or "Required if Applicable", and (2) "Standard" or "Enhanced". Furthermore, each field within each table of the DFIRM database is categorized by the same two classifications.

The first method of characterizing tables in the DFIRM database is whether they are designated "Required" for all Flood Map Projects (FMP) or "Required if Applicable." If a table is designated "Required if Applicable," then the Mapping Partner must only submit that table if it is applicable to that project (*e.g.*, the Mapping Partner is required to submit PLSS boundary data if it was used in producing the FIRM, which would not be applicable in Texas). Moreover, if a field within a table is designated "Required," then the Mapping Partner must assign a value to that field for that database.

The standard DFIRM database is simply a subset of the enhanced DFIRM database, where the standard DFIRM database includes only the mapping elements of a FIRM and the enhanced DFIRM database is the entire DFIRM database which is intended to include the FIRM mapping elements as well as the supporting engineering data used to develop the FIRM. This distinction was intended to be mostly relevant to end-users who may or may not be interested in the supporting engineering (enhanced) data.

2.1.3 DFIRM Database Tables

Tables within the DFIRM database are also classified by three GIS types. The first are tables containing data pertaining to spatial features, which are called "spatial" tables and are given a prefix of "S_" in the table name. Second, tables that contain data entries *without* a spatial feature are called "lookup" tables and are given a prefix of "L_" in the table name. The third type is tables that only serve to define the set of valid entries of certain fields in spatial and lookup tables, which are called “domain” tables and are assigned a prefix of “D_” in the table name. The lookup and domain tables are simply “flat” tables of information. The spatial tables, however, include an additional “geometry” file (of which there are several acceptable formats, though shapefile is preferred), that describes the geometry of each feature (entry) in the table.

A summary of the spatial, lookup, and domain tables is presented in Table 2.1, Table 2.2, and Table 2.3, respectively. The second column in Table 2.1 describes the geometry type of each spatial table. In Table 2.1 and Table 2.2, the “Draft” and “Final” columns refer to the page number of the attribute table in Appendix L for the Draft and Preliminary/Final version, respectively. The second and third columns in Table 2.3 refer to the location of the attribute table and the valid entry-code pair tables, respectively. In addition, each DFIRM database table is classified as “Standard” (S), “Enhanced” (E), or both (S&E) if the table has Standard fields and Enhanced fields. The final column in the following tables provides a brief description of each DFIRM database table. Data in the first and last columns in Table 2.1 and Table 2.2 were adapted from Table L-1 of Appendix L (FEMA, 2003, Appendix L, p. L-18 – L-19).

Table 2.1 DFIRM Database Spatial Tables

Table Name	Geometry	Draft	Final	S / E	Table Description (Information about …)
S_Base_Index	Polygon	L-56	L-270	S	a tiling index for raster data used for the DFIRM
S_BFE	Line	L-58	L-272	S	base flood elevations lines shown on DFIRM
S_CBRS	Polygon	L-60	L-274	S	Coastal Barrier Resource System units on the DFIRM
S_Cst_Gage	Point	L-62	L-276	E	the coastal gages for the study area
S_Cst_Tsct_Ln	Line	L-65	L-279	S&E	coastal transect lines shown on the DFIRM
S_FIRM_Pan	Polygon	L-72	L-286	S	DFIRM hardcopy map panels
S_Fld_Haz_Ar	Polygon	L-77	L-291	S&E	flood insurance risk zones on the DFIRM
S_Fld_Haz_Ln	Line	L-82	L-296	S	boundaries of flood insurance risk zones on the DFIRM
S_Gen_Struct	Line	L-84	L-298	S	flood control structures shown on the DFIRM
S_Label_Ld	Line	L-86	L-300	S	leader lines on transportation and hydrography labels on the DFIRM
S_Label_Pt	Point	L-89	L-302	S	transportation and hydrography labels shown on the DFIRM
S_LOMR	Polygon	L-90	L-304	S&E	LOMRs on the DFIRM
S_Nodes	Point	L-92	L-306	E	points used to define the topology of the hydrologic network
S_Ovrbnkln	Line	L-94	L-308	E	the overbank flow lines features for the study area
S_Perm_Bmk	Point	L-96	L-310	S	bench marks on the DFIRM
S_PFD_Ln	Line	L-98	L-312	E	the primary frontal dune features for the coastal study area
S_PLSS_Ar	Polygon	L-100	L-314	S	sections, townships and ranges on the DFIRM
S_PLSS_Ln	Line	L-103	L-317	S	section lines, township lines and range lines on the DFIRM
S_Pol_Ar	Polygon	L-106	L-320	S	political jurisdictions shown on the DFIRM
S_Pol_Ln	Line	L-109	L-323	S	political boundaries shown on the DFIRM
S_Precip_Gage	Point	L-111	L-325	E	rain gages used in developing the hydrologic analysis
S_Profil_Basln	Line	L-113	L-327	E	profile baseline and stream centerline features for the study area
S_Quad_Index	Polygon	L-116	L-330	S	USGS quadrangle maps covering the DFIRM area
S_Riv_Mrk	Point	L-118	L-332	S	river mile markers shown on the DFIRM
S_Shore_Ln	Line	L-120	L-334	E	the shoreline used in the coastal flood hazard model
S_Stn_Start	Point	L-122	L-336	E	station points
S_Subbasins	Polygon	L-124	L-338	E	subbasins in the hydrologic analysis
S_Trnsport_Ln	Line	L-126	L-340	S	roads, railroads and other transportation features shown on the DFIRM
S_Water_Gage	Point	L-129	L-343	E	non-rain gages used in developing the hydrologic analysis
S_Wtr_Ar	Polygon	L-131	L-345	S	hydrography features shown on DFIRM
S_Wtr_Ln	Line	L-134	L-347	S	hydrography features shown on DFIRM
S_XS	Line	L-137	L-350	S&E	cross-section lines in the area covered by the DFIRM

Table 2.2 DFIRM Database Lookup Tables

Table Name	Draft	Final	S / E	Table Description (Information about …)
Study_Info	L-142	L-355	S&E	General information about the DFIRM
L_Aux_Data	L-147	L-360	E	auxiliary data
L_Case_Info	L-150	L-363	E	data specific to the study
L_Comm_Info	L-152	L-365	S	each community on the DFIRM
L_Cst_Model	L-155	L-368	E	coastal models used in the engineering analysis
L_Hydra_Model	L-159	L-372	E	hydraulic models used in the engineering analysis
L_Hydro_Model	L-161	L-374	E	hydrologic models used in the engineering analysis
L_Media	L-163	L-376	E	archived media that is linked to a spatial object
L_MT1_LOMC	L-165	L-378	S	LOMCs on the DFIRM
L_Node_Disch	L-167	L-381	E	hydrologic routing
L_Pan_Revis	L-169	L-383	S	revisions to each FIRM panel
L_Pol_FHBM	L-171	L-385	S	revisions to FHBMs for each community
L_Regression	L-173	L-387	E	regression equations utilized in the hydrologic modeling
L_Stn_Start	L-175	L-389	S	starting points for stream distance measurements
L_Storm_Curve	L-177	L-391	E	Depth-Duration-Frequency and Intensity-Duration-Frequency relationships
L_Storm_Info	L-179	L-393	E	basic precipitation patterns
L_Subbas_Disch	L-181	L-395	E	outflow data for each subbasin and recurrence interval in hydrologic analyses
L_Wtr_Nm	L-183	-	S	hydrographic features on the DFIRM
L_XS_Ratings	L-185	L-397	E	cross sections

Table 2.3 DFIRM Database Domain Tables

Table Name	Attrib.	Codes	S / E	Table Description (valid entries for ...)
D_Area_Units	L-189	L-411	E	units of area measurment
D_CBRS_Typ	L-191	L-412	S	Coastal Barrier Resources System (CBRS) area types
D_Chan_Rep	L-193	L-413	S	channel cartographic representations: single (centerline) or double (banks)
D_Discharge_Units	L-195	L-414	E	units of discharge measurement
D_Eros_Method	L-197	L-415	E	erosion methodologies of dunes in coastal flood analysis
D_Floodway	L-199	L-416	S	floodway types
D_Frequency	L-201	L-417	E	storm event frequency types
D_Gage	L-203	L-418	E	precipitation, water, and coastal gage types
D_Hydra	L-205	L-419	E	hydraulic models
D_Hydro	L-207	L-421	E	hydrologic models
D_Label_Typ	L-209	L-423	S	FIRM cartographic leader types
D_Length_Units	L-211	L-424	S&E	units of length measurement
D_Ln_Typ	L-213	L-425	S	cartographic line types (flood hazard, political, and PLSS lines)
D_Method	L-215	L-427	E	coastal transect station and elevation methodologies
D_Nm_Typ	L-217	L-428	S	road name types (e.g., highway, interstate, parkway, road, etc.)
D_Nodes	L-219	L-431	E	hydrologic model network node types (e.g., junction, reservior, structure, etc.)
D_Panel_Typ	L-221	L-432	S	FIRM panel types (e.g., printed, not-printed, community, countywide, etc.)
D_Rd_Stat	L-223	L-433	S	road status types (e.g., paved, proposed, under construction, etc.)
D_Runup_Mdl	L-225	L-434	E	wave runup models in coastal flood analysis
D_Scale	L-227	L-435	S	FIRM cartographic scales
D_Shr_Rough	L-229	L-436	E	shoreline roughness types in coastal flood analysis
D_Shr_Typ	L-231	L-437	E	shoreline development methods
D_Storms	L-233	L-438	E	storm types in hydrologic models
D_Struct_Typ	L-235	L-439	S	hydraulic structure types
D_Surge_Mdl	L-237	L-441	E	hurricane surge models in coastal flood analysis
D_Time_Units	L-239	L-442	E	units of time measurement
D_Trans_Typ	L-241	L-443	S	transportation types (e.g., road, railroad, airport, ferry, etc.)
D_V_Datum	L-243	L-444	S&E	vertical datums (NAVD88 or NGVD29)
D_Velocity_Units	L-245	L-445	S&E	units of velocity measurement
D_Volume_Units	L-247	L-446	E	units of volume measurement
D_VZone	L-249	L-447	E	V Zone development methods in coastal flood analysis
D_Water_Typ	L-251	L-448	S&E	water feature types (e.g., creek, reservior, lake/pond, stream/river, etc.)
D_Wave_Mdl	L-253	L-451	E	wave height models in coastal flood analysis
D_Zone	L-255	L-452	S	flood hazard zone types

Though not specifically stated in Appendix L, the DFIRM database essentially has several unofficial data groups, in addition to the mapping components on a FIRM. Several spatial and lookup tables describe coastal flood hazard mapping data, and several others form a rather ambiguous group of engineering data that create the Enhanced DFIRM.

Each spatial and lookup table contains a “primary key” field, which must contain a unique identifier for each entry within the table (usually an incrementing integer value). Primary keys (as well as many other fields) within the DFIRM are specified as a “Text” field type with an 11-character length. Relationships between tables are developed by including a “foreign key” field in the “Destination” table, in which the primary key value is recorded from the “Origin” table. As a general DFIRM design rule, fields within spatial and lookup tables that have a field name suffix of “_ID” are foreign keys to another spatial or lookup table. Similarly, fields in the Draft DFIRM database version that have a field name suffix of “_LID” are foreign keys to a domain table (the Preliminary/Final DFIRM database does not use domain tables.) An example of primary and foreign key relationships is presented in Figure 2.1 using the S_Wtr_Ln table and related tables. For each entry within the S_Wtr_Ln table, the foreign key fields reference three other tables (D_Water_Typ, D_Chan_Rep, and L_Wtr_Nm), which control the list of valid entries for that field.

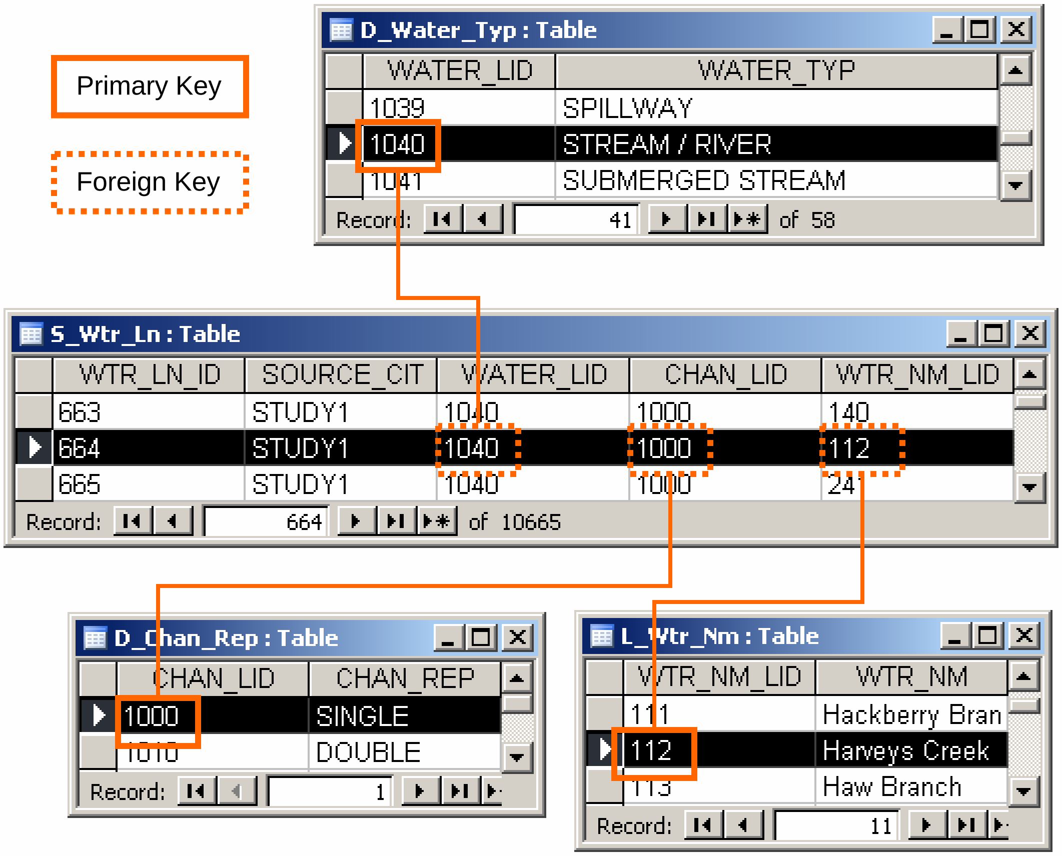


Figure 2.1 Primary and Foreign Key Relationship in S_Wtr_Ln (Draft DFIRM)

2.1.4 Mapping Partner Requirements - DFIRM Database Deliverables

FEMA recognizes that most Flood Hazard Mapping Projects will not use the complete set of tables in the DFIRM database. For instance, most mapping projects of the inland contiguous United States will not require any coastal data. Also, there may be lesser demand for complete flood hazard analyses in less populated areas, which would probably not utilize the complete DFIRM database. Appendix L specifies the tables that are required for submittal based on the level of detail of the project, which is summarized in Table 2.4 (adapted from FEMA, 2003, Appendix L, Table L-2, pp. L-20 – L-21).

Table 2.4 DFIRM Table Submittal Requirements for Mapping Projects

Digital FIRM Preparation & Maintenance	Hydrologic & Hydraulic Analyses and Mapping	Coastal Hazard Analyses and Mapping	Digital Base Map Development	Refinement of Approximate Zone A Boundaries
S_Base_Index			S_Base_Index	
S_BFE	S_BFE	S_BFE		
S_CBRS		S_CBRS		
S_Cst_Gage		S_Cst_Gage		
S_Cst_Tsct_Ln		S_Cst_Tsct_Ln		
S_FIRM_Pan				
S_Fld_Haz_Ar	S_Fld_Haz_Ar	S_Fld_Haz_Ar		S_Fld_Haz_Ar
S_Fld_Haz_Ln	S_Fld_Haz_Ln	S_Fld_Haz_Ln		S_Fld_Haz_Ln
S_Gen_Struct	S_Gen_Struct	S_Gen_Struct	S_Gen_Struct	
S_Label_Ld			S_Label_Ld	
S_Label_Pt			S_Label_Pt	
S_LOMR	S_LOMR	S_LOMR		S_LOMR
S_Nodes	S_Nodes			
S_Ovrbnkln	S_Ovrbnkln			
S_Perm_Bmk	S_Perm_Bmk	S_Perm_Bmk	S_Perm_Bmk	S_Perm_Bmk
S_PFD_Ln		S_PFD_Ln		
S_PLSS_Ar			S_PLSS_Ar	
S_PLSS_Ln			S_PLSS_Ln	
S_Pol_Ar			S_Pol_Ar	
S_Pol_Ln			S_Pol_Ln	
S_Precip_Gage	S_Precip_Gage			
S_Profil_Basln	S_Profil_Basln			
S_Quad_Index			S_Quad_Index	
S_Riv_Mrk	S_Riv_Mrk			
S_Shore_Ln		S_Shore_Ln		
S_Stn_Start	S_Stn_Start			
S_Subbasins	S_Subbasins			
S_Trnsport_Ln			S_Trnsport_Ln	
S_Water_Gage	S_Water_Gage			
S_Wtr_Ar	S_Wtr_Ar	S_Wtr_Ar	S_Wtr_Ar	S_Wtr_Ar
S_Wtr_Ln	S_Wtr_Ln	S_Wtr_Ln	S_Wtr_Ln	S_Wtr_Ln
S_XS	S_XS			
Study_Info				
L_Aux_Data	L_Aux_Data	L_Aux_Data		
L_Case_Info	L_Case_Info			
L_Comm_Info				
L_Cst_Model		L_Cst_Model		
L_Hydra_Model	L_Hydra_Model			
L_Hydro_Model	L_Hydro_Model			
L_Media	L_Media	L_Media		
L_MT1_LOMC				
L_Node_Disch	L_Node_Disch			
L_Pan_Revis				
L_Pol_FHBM				
L_Regression	L_Regression			
L_Stn_Start	L_Stn_Start			
L_Storm_Curve	L_Storm_Curve			
L_Storm_Info	L_Storm_Info			
L_Subbas_Disch	L_Subbas_Disch			
L_Wtr_Nm	L_Wtr_Nm	L_Wtr_Nm	L_Wtr_Nm	L_Wtr_Nm
L_XS_Ratings	L_XS_Ratings			

For most FEMA regions, Mapping Partners were submitting only the Digital Base Map Development tables (listed in the fourth column of Table 2.4) until mid-2005 when FEMA began phasing in enforcement of the Data Capture Standards.

2.2 Appendix N – Data Capture Standards (DCS)

A Draft of Appendix N was written in 2004 and originally published in April of 2004. A revised version of Appendix N was published in December of 2004, and yet another version was published in May of 2005.

2.2.1 Purpose and Organization

A summary of the purpose of the Data Capture Standards (DCS) is presented in the introductory section of *Appendix N* of the *Guidelines and Specifications for Floodplain Mapping Partners* (FEMA, 2005, Appendix N, pp. N-1 – N-2):

> The purpose of the Data Capture Standards (DCS) in this Appendix is to provide a consistent framework for collection, analysis, storage and retrieval of the data needed for a Flood Insurance Study (FIS) or Flood Insurance Rate Map (FIRM) revision. Providing this framework is intended to make the study assessment process more efficient; make the data more available for future use; and preserve the investment made in the data. It is part of a 5-year plan to collect and provide data to the Mapping Information Platform (MIP) for sharing through the data federation.
>
> For those Mapping Partners that use the engineering and mapping tools provided by FEMA, the required data will be automatically archived in the recommended format. In the case of Mapping Partners who have developed other automated processes for performing production style flood mapping, these data standards serve as the mechanism for collecting and archiving the required data.
>
> These data standards are the vehicles used to help collect and manage the engineering deliverables that result from the flood insurance study process. The DCS also facilitate the building of an Enhanced Digital Flood Insurance Rate Map (DFIRM) database by providing information that is needed in manageable pieces during the progression of the mapping process. The DCS will also support queries to the MIP that will track and evaluate progress metrics on studies and report these metrics to the process stakeholders.
>
> Similarities have been drawn between the DCS in this Appendix and Appendix L of these Guidelines. The clear difference between Appendix L and the DCS is

> that the DCS is a collection of databases for use as part of the intermediate processes of creating a DFIRM. Appendix L is associated with the output and final deliverables of the flood hazard mapping.
>
> There is some overlap between the two data standards, specifically in areas where the DCS, once capture points have been reached, reports end result data. There are also places where the two datasets have no overlap at all. Examples of this would be how Appendix L captures data such as planimetric data and pre-/post-Preliminary DFIRM mapping information. Conversely, the DCS stores data types such as terrain processing and field survey information, neither of which are stored in Appendix L tables.
>
> As a part of the ongoing review and refinement of all FEMA datasets, Appendix L of these Guidelines and the DCS will undergo a review to specifically see how best to account for the data stored in the two datasets and how this can be made clearer to all Mapping Partners. The result of this review could involve refinements to the datasets or the joining of the data into one comprehensive dataset.
>
> In the interim, Mapping Partners should submit DCS tables defined in this appendix for all re-modeled areas. All Standard Appendix L tables should be submitted for the entire community or county being mapped.
> (FEMA, 2005, Appendix N, pp. N-1 – N-2)

Appendix N includes four sections after the introduction that explain the four major data groups within the DCS database: terrain, survey, hydrology, and hydraulics. The terrain section describes the archival of digital topographic data used in the FIS. The survey section describes spatial and lookup tables that represent survey data regarding channel geometry and structures such as dams, culverts, and bridges. The hydrology section describes spatial and lookup tables that document hydrologic descriptions and models of watersheds contributing to study streams. The hydraulic section describes spatial and lookup tables that describe channel features and hydraulic models used in the FIS.

2.2.2 DCS Database Structure

Since the DCS database was intended to be a more detailed extension of the Enhanced portion of the DFIRM database, the designers created the DCS database to closely resemble the DFIRM database. For instance, table names include a prefix of "S_" for spatial, "L_" for lookup, and "D_" for domain. Also, names of foreign key fields to other spatial and lookup tables have a suffix of "_ID", and field names of foreign keys to domain tables have a suffix of "_LID". In fact, many of the DCS database tables have foreign key fields to DFIRM database tables. A summary of spatial, lookup, and domain tables specified in the DCS is presented in Table 2.5, Table 2.6, Table 2.7, respectively. These tables record the location of the attribute table and a brief description of each DCS table.

Although there is a Terrain data group within the DCS database, the tables only specify auxiliary information about terrain models. There is currently such a wide variety of terrain models that FEMA does not restrict Flood Mapping Partners to a specific format. There are two spatial tables that are most important to the Terrain data group. The S_Perimeter and L_PerimFile tables define the spatial extent of terrain data and information about the type and source of that terrain data. For instance, in a countywide Flood Hazard Mapping Project, the Mapping Partner may receive and use high-resolution terrain data from a large city and use less precise terrain data (*e.g.*, USGS 10-feet contours) for the remainder of the county. The S_TileIndex table is a lattice of rectangular tiles that cover the extent of the Flood Hazard Mapping Project terrain model. Some software utilizes this tile system to partition large datasets, and only access the required subset of data for improved processing performance.

Table 2.5 DCS Database Spatial Tables

Table Name	Page	Geometry	Table Description (Information about …)
Contour	N-13	Line	elevation contour lines in a terrain model
S_ApxStr	N-65	Line	structures of limited detail surveys
S_BFE	N-109	Line	base flood elevation
S_ExternalBoundary	N-16	Polygon	define outer extents of a TIN model
S_HWM	N-34	Point	high water marks
S_HydraCrossSection	N-104	Line	hydraulic stream cross-sections
S_HydraFlowPath	N-110	Line	alternative model stream baseline
S_HydraJunction	N-111	Point	alternative model network junctions
S_HydraMapping	N-108	Line	draft floodway and flood boundaries
S_HydraNvalue	N-112	Polygon	Manning's N roughness regions along streams
S_HydroBasin	N-85	Polygon	precipitation drainage basins
S_HydroGage	N-87	Point	precipitation and stream flow gages
S_HydroImpervious	N-89	Polygon	areas of impervious cover
S_HydroLandUse	N-88	Polygon	land use classification regions
S_HydroLink	N-83	Line	hydrologic modeling schematic link
S_HydroNode	N-83	Point	hydrologic modeling schematic node
S_HydroSoil	N-88	Polygon	soil type classification regions
S_HydroTC	N-89	Line	time of concentration flow paths
S_Island	N-16	Polygon	TIN region within a void area
S_NoData	N-15	Polygon	"no data" regions in a DEM
S_Ovrbnkln	N-113	Line	overbank flow lines
S_Perimeter	N-12	Polygon	perimeter of each terrain dataset
S_Photo	N-27	Point	survey photographs
S_RefPoint	N-105	Point	origin for distance measurements along a stream
S_SinkBreach	N-14	Line	lines used to hydrologically correct DEM sinks
S_StreamCntrLine	N-103	Line	stream centerline for hydrologic and hydraulic studies
S_StreamsDEM	N-17	Line	stream network from the DEM
S_Struc	N-42	Line	structures of detail surveys
S_SXS	N-28	Point	surveyed stream cross-sections
S_TBM	N-31	Point	temporary survey bench mark
S_TileIndex	N-9	Polygon	index tiles of tiled terrain data
S_VoidArea	N-15	Polygon	used to delete unwanted points before building TINs

Table 2.6 DCS Database Lookup Tables

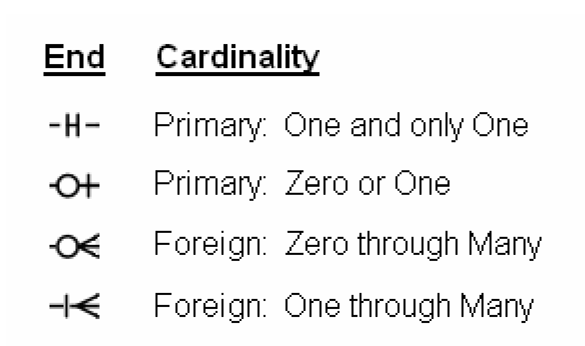
Table Name	Page	Table Description (Information about …)
L_ApxBrdg	N-70	approximate survey of bridges
L_ApxCul	N-66	approximate survey of culverts
L_ApxDam	N-67	approximate survey of dams
L_ApxPht	N-69	photos associated with approximate surveys
L_ApxRsr	N-68	approximate survey of dam risers
L_ApxSwy	N-69	approximate survey of spillways
L_Brdg	N-44	survey of bridges
L_CulPp	N-45	survey of culvert pipes
L_Dam	N-46	survey of dams
L_HWMPht	N-35	photos associated with High Water Mark surveys
L_HWMSkt	N-35	sketches associated with High Water Mark surveys
L_HWMWtns	N-35	interview of witnesses of High Water Marks
L_HydraEvent	N-107	precipitation event in hydraulic modeling
L_HydraFloodResult	N-106	hydraulic modeling results for each cross-section and event pair
L_HydraModel	N-102	hydraulic models used in flood hazard analysis
L_HydraXsPt	N-112	x, y, and z of points defining each hydraulic cross-section
L_HydroCNLookup	N-92	curve numbers for soil type, condition, and land use combinations
L_HydroCNResult	N-91	composite curve number for each hydrologic basin
L_HydroEquation	N-90	precipitation regression equations in hydrologic analysis
L_HydroEvent	N-86	precipitation event in hydrologic modeling
L_HydroModel	N-82	hydrologic models used in flood hazard analysis
L_HydroNodeParam	N-90	regression parameters associated with hydrologic nodes
L_HydroResult	N-85	hydrologic model results (discharge) for nodes and basins
L_HydroStormCurve	N-94	hydrograph parameters in hydrologic analysis
L_HydroStormInfo	N-93	spatial distribution of precipitation in hydrologic analysis
L_LChrd	N-47	survey of low chord shots on bridges
L_Levee	N-48	survey of levees
L_Orfc	N-49	survey of orifices on dam risers
L_OtlPp	N-50	survey of outlet pipes from dam risers
L_PerimFile	N-12	files defining perimeter of terrain data
L_Pier	N-51	survey of bridge piers
L_Rail	N-51	survey of structure rails
L_RsrBrl	N-52	survey of riser barrels
L_Sketch	N-26	survey sketches
L_StrPht	N-53	photos associated with structures
L_StrSkt	N-53	sketches associated with structures
L_Submittal_Info	N-5	Flood Hazard Mapping Project and Mapping Partner
L_SWy	N-53	survey of spillways
L_SXS	N-25	survey of cross-sections
L_SXSPht	N-26	photos associated with cross-sections
L_SXSSkt	N-26	sketches associated with cross-sections
L_Wtr_Nm	N-27	names of hydrographic features

Table 2.7 DCS Database Domain Tables

Table Name	Page	Table Description (valid entries for ...)
D_AbtTyp	N-56	abutment types (e.g., spill through or vertical wall)
D_ClsTyp	N-58	structure closure type (e.g., floodgates, sandbags, etc.)
D_DamTyp	N-59	dam types (e.g., earthfill, masonry, RCC, rockfill, etc.)
D_DatTyp	N-28	Cross-section types (field or top of road)
D_HWLnTp	N-37	High Water Mark types (e.g., mud, debris, etc.)
D_HydroParam	N-91	hydrologic regression parameters and units
D_LevTyp	N-58	levee types (e.g., floodwall, levee, road, railroad, etc.)
D_MtlTyp	N-57	construction material types (e.g., gravel, earthen, concrete, etc.)
D_PpTyp	N-57	pipe end types (e.g., socket, projecting from fill, bell, etc.)
D_ShpTyp	N-56	shape types (e.g. circular, rectangular, trapezoidal, etc.)
D_SwyTyp	N-59	spillway types (e.g., emergency, service/principal, etc.)

The Survey data group includes surveyed cross-sections, surveyed high water marks (HWM), detailed surveyed structures, and approximate surveyed structures. The relationship diagram from Appendix N is presented for the surveyed cross-sections data subgroup in Figure 2.3 (FEMA, 2005, Appendix N, p. N-24). Within the relationship diagram, the left column in each table identifies a field as a primary key (PK) or foreign key (FK). The dashed lines that connect tables represent relationships, and the symbols at the ends of each line define the cardinality of the relationship according to Figure 2.2.

Figure 2.2 DCS Relationship Diagram Cardinality Key



Stream cross-sections are surveyed by recording the X, Y, and Z location of multiple points across a stream channel and overbank in relation to a Temporary Benchmark (TBM).

Information about each cross-section is stored in the L_SXS table, and each survey point along a cross-section is recorded in the S_SXS table. The location of the TBM for each cross-section is stored in the S_TBM table. Each cross-section is related to the water feature (L_Wtr_Nm) it describes, and potentially a nearby hydraulic structure (S_Struc). Filenames of sketches and photos of the cross-section are stored in the L_Sketch and S_Photo tables. Each point in the S_Photo table represents the location where the photographer was standing when the photo was taken.

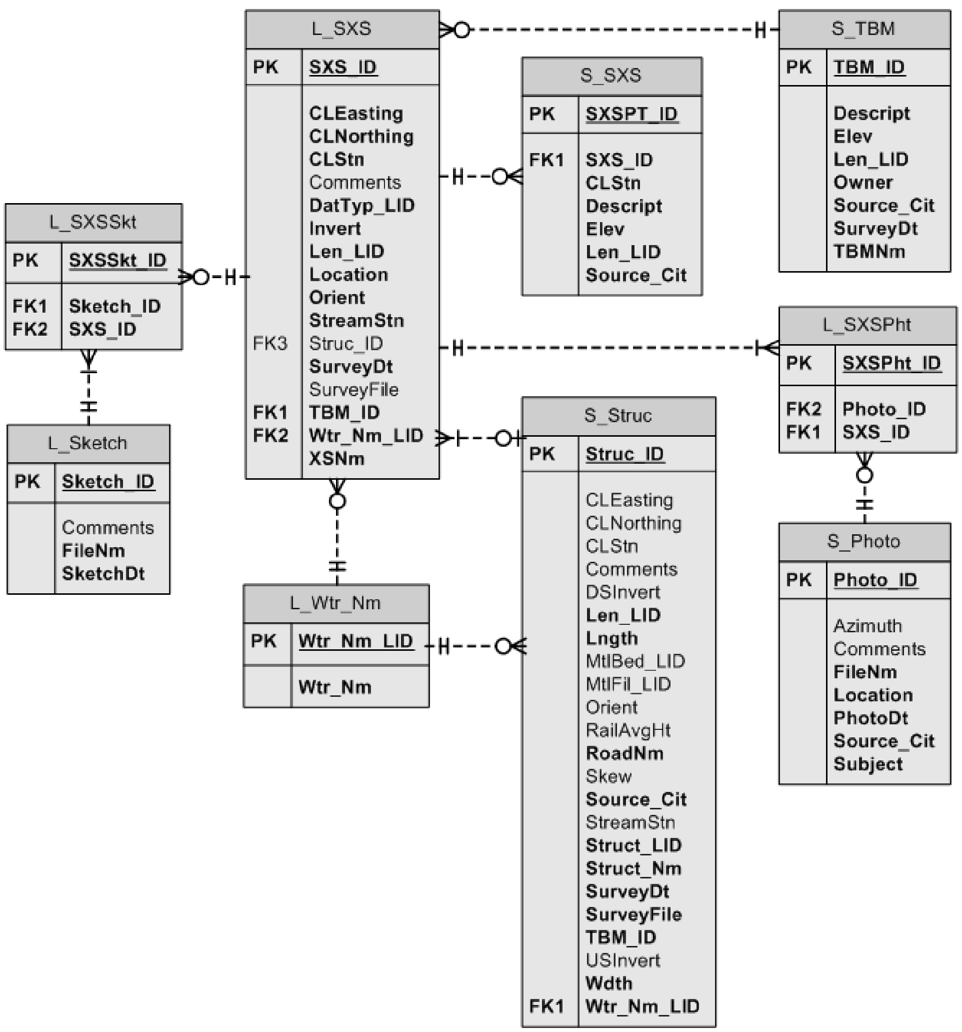


Figure 2.3 DCS Relationship Diagram for Cross-Sections

High Water Marks (HWMs) are usually mud or debris lines remaining after floods that identify the maximum water surface elevation, and these HWMs are sometimes used in the calibration of hydraulic models. The relationship diagram from Appendix N is presented the HWM data subgroup in Figure 2.4 (FEMA, 2005, Appendix N, p. N-33). The location of a surveyed HWM point is recorded in the S_HWM table, and information about the person who witnessed the HWM is recorded in the L_HWMWtns table. Each HWM is related to the water feature (L_Wtr_Nm) it describes. Filenames of sketches and photos of a HWM are stored in the L_Sketch and S_Photo tables.

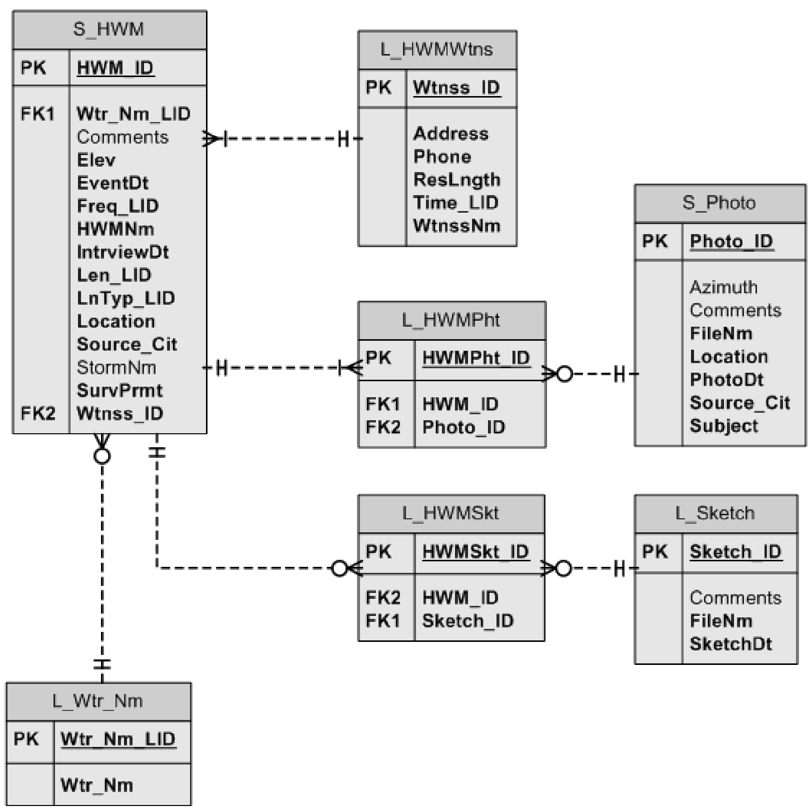


Figure 2.4 DCS Relationship Diagram for High Water Marks

Recording information from the survey of hydraulic structures involves many tables in the DCS, and there are two categories of structures: approximate and detailed. The *approximate* survey method is not as exhaustive as the detailed survey method; a team can perform about ten approximate surveys in the time it takes to perform one detailed survey, and the ratio of cost is approximately ten as well. However, in terms of hydraulic analysis and modeling, an approximate survey of a structure provides most of the necessary information to model the hydraulic impact of the structure. In a comparison of the accuracy of enhanced-approximate (also called limited-detail) studies and detail studies, Watershed Concepts™ summarizes the comparison:

> The limited-detail study process differs from the detailed study process in three significant ways:
>
> ▪ Structures are not surveyed – data is obtained from simplified bridge, culver, and dam measurements including openings, number of piers or barrels, hydraulic width, and invert.
>
> ▪ Channels are taken to be trapezoidal with dimensions determined from rating curves relating channel width and depth to drainage area; there are no surveyed cross-sections.
>
> ▪ n-value data is generalized – values are determined using aerial photography where available.
>
> …
>
> It is found that whether calibrating to several high water marks or running a fresh model without use of existing detailed data, limited-detail studies can be an acceptably accurate alternative to more costly, time consuming studies. (Watershed Concepts™, 2003, p. 1)

Instructions and procedures for performing approximate and detailed surveys are provided to Mapping Partners in the second part of Appendix N: *Data Capture Guidelines* (FEMA, 2005, Appendix N).

The relationship diagram from Appendix N is presented for the Approximate Structures data subgroup in Figure 2.5 (FEMA, 2005, Appendix N, p. N-63). A line feature records the location and orientation of each hydraulic structure in the S_ApxStr table. Each structure is associated with the water feature (L_Wtr_Nm) on which it lies. Depending on what type of structure it is (bridge, culvert, or dam), one of the approximate lookup tables (L_ApxBrdg, L_ApxCul, and L_ApxDam) records information about the structure. If a particular structure is a dam, then additional information may be recorded about risers and spillways in the L_ApxRsr and L_ApxSWy tables. Filenames of photos of the structure and the location of where the photographer took the photograph are recorded in the S_Photo table.

The *detailed* structures data subgroup is similar to, but more extensive than the approximate structures. The relationship diagram from Appendix N is presented for the Detailed Structures data subgroup in Figure 2.6 (FEMA, 2005, Appendix N, p. N-41). The S_Struc table records the location and orientation of each detailed hydraulic structure with a line feature, and the S_Struc table is the central component of the detailed structures data subgroup. Each detailed structure is related to the water feature (L_Wtr_Nm) on which it lies, and is also associated with surveyed cross-sections (S_SXS) upstream and downstream of the structure. Filenames of sketches and photos of each structure are recorded in the L_Sketch and S_Photo tables.

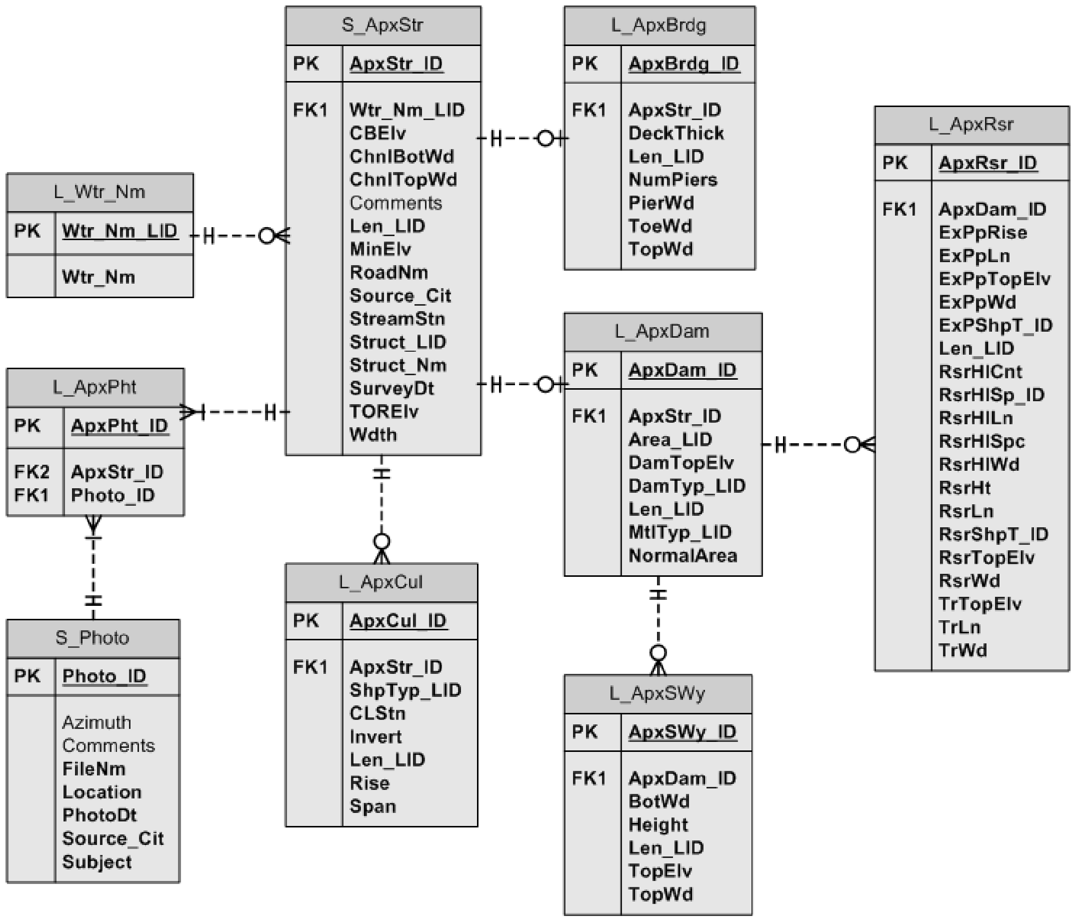


Figure 2.5 DCS Relationship Diagram for Approximate Structures

Information about rails and culverts on structures is recorded in the L_Rail and L_CulPp tables. Depending on what type of detailed structure it is (bridge, dam, or levee), one of the detailed structure lookup tables (L_Brdg, L_Dam, and L_Levee) records information about the structure. If a particular structure is a bridge, then additional information may be recorded about piers and low chord surveys in the L_Pier and L_LChrd tables. If a particular structure is a dam, then additional information may be recorded about risers and spillways in the L_RsrBrl and L_SWy tables. Additional information about outlet pipes and orifices on riser barrels is recorded in the L_OtlPp and L_Orfc tables, respectively.

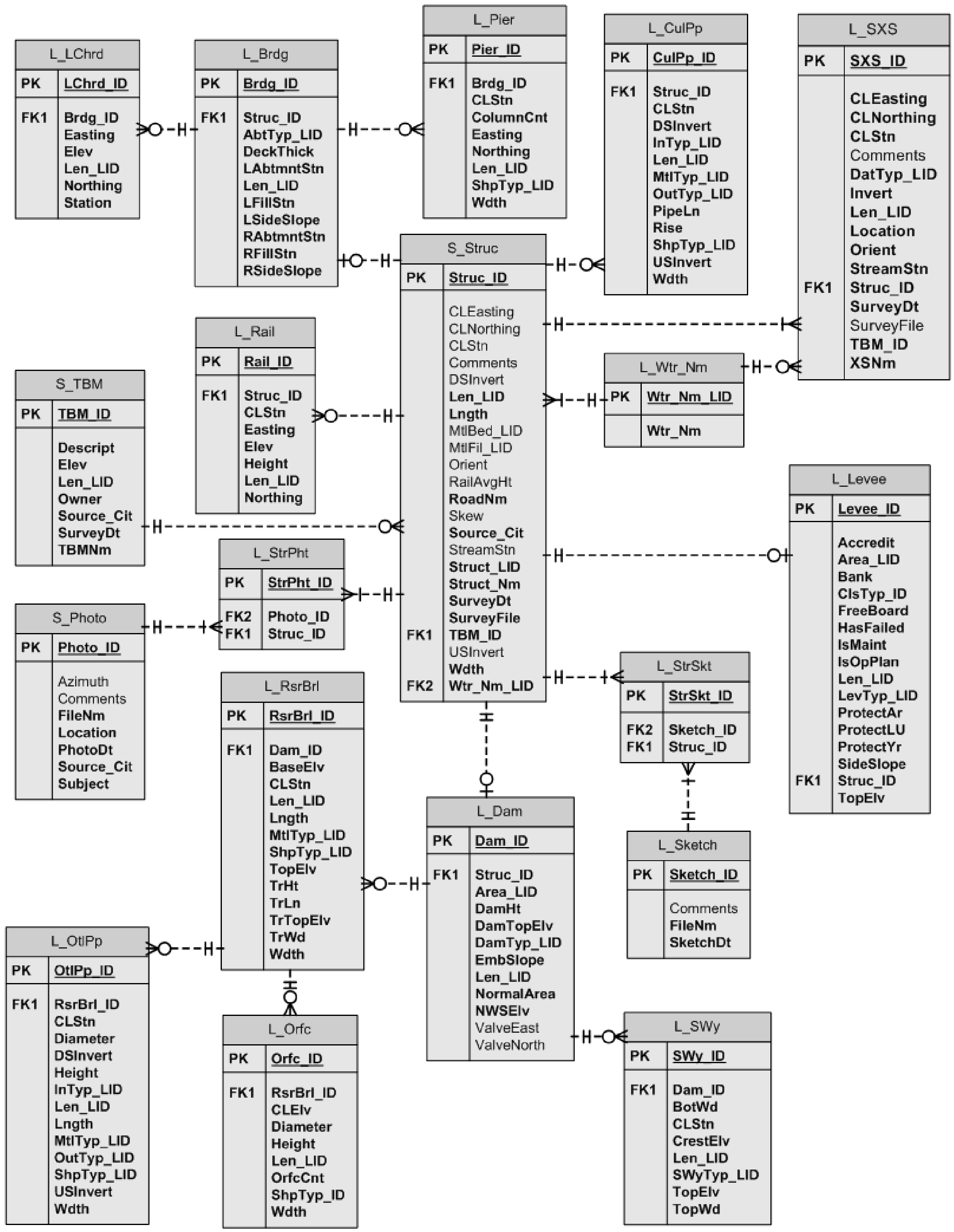


Figure 2.6 DCS Relationship Diagram for Detailed Structures

The DCS relationship diagram for the Hydrology data group is presented in Figure 2.7 (FEMA, 2005, Appendix N, p. N-81). The core spatial tables of the Hydrology data group are the S_HydroBasin and S_HydroNode tables. The S_HydroBasin records the spatial extent of delineated watersheds, and the S_HydroNode table records the location of pour points (basin drainage points) and other nodes used in hydrologic modeling. The L_HydroEvent table records the probability of a modeled storm (*e.g.*, 1% annual), and the L_HydroStormInfo and L_HydroStormCurve tables record information about the spatial and temporal distribution of precipitation in rainfall-runoff models. If precipitation regression equations are used instead of a rainfall-runoff model, then regression equations are stored in the L_HydroEquation table and regression equation parameters and node values are stored in the D_HydroParam and L_HydroNodeParam tables. If schematic links are used in hydrologic modeling, then the links are recorded in the S_HydroLink table. The L_HydroModel table records information about the hydrologic model used, and the L_HydroResult table records the discharge value at each node resulting from hydrologic modeling. The S_HydroGage table records information about precipitation and streamflow gages used in hydrologic analysis and modeling. The S_HydroImpervious, S_HydroSoil, and S_HydroLandUse tables record information about impervious cover, hydrologic soil type, and land use characterization. Various combinations of these data are associated with a specific curve number value and recorded in the L_HydroCNLookup table. A composite curve number is recorded in the L_HydroCNResult table for each basin in a rainfall-runoff model.

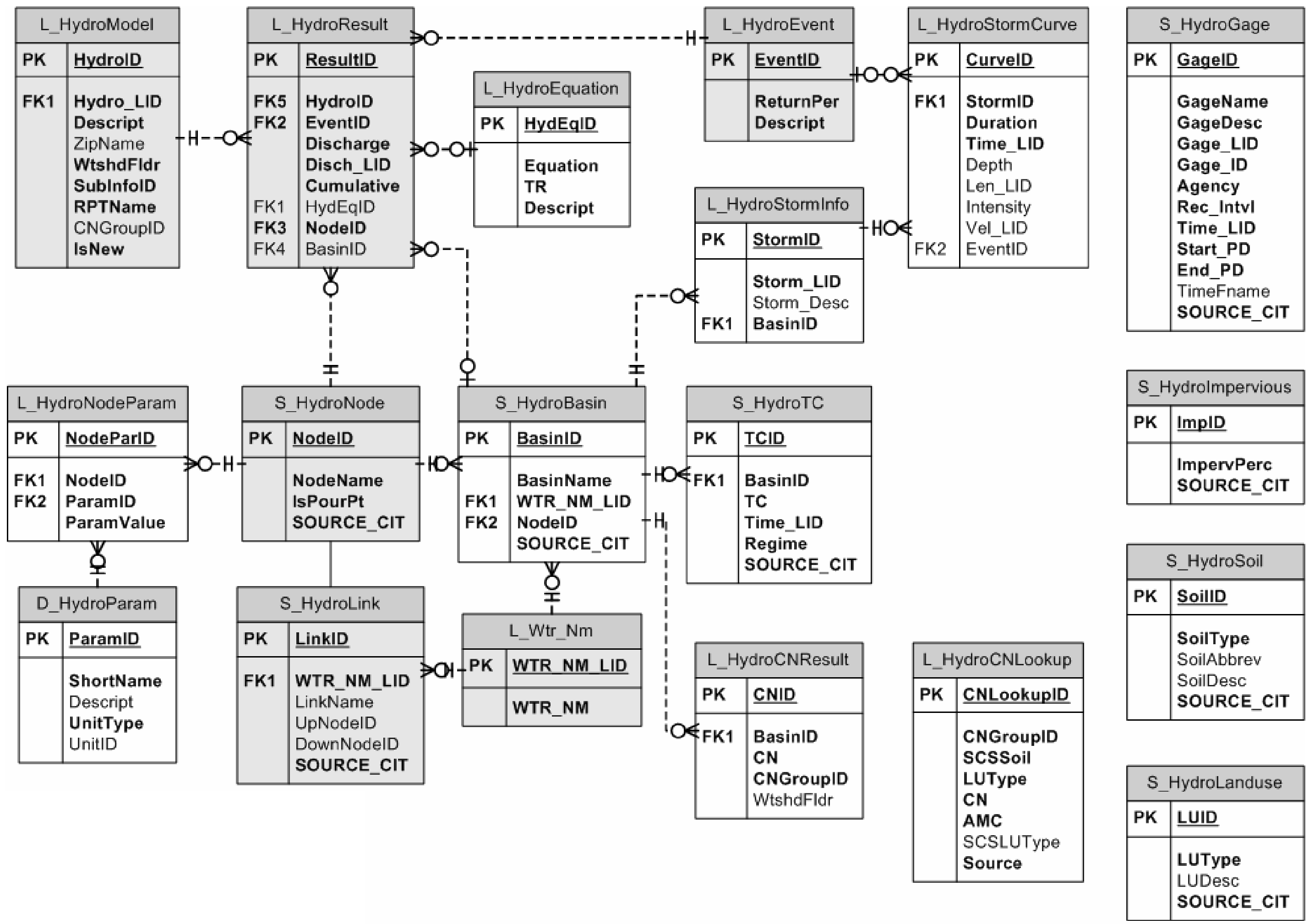


Figure 2.7 DCS Relationship Diagram for Hydrology

The DCS relationship diagram for the Hydraulics data group is presented in Figure 2.8 (FEMA, 2005, Appendix N, p. N-101). The core spatial tables in the Hydraulics data group are the S_StreamCntrLine and S_HydraCrossSection tables, which store the centerline of streams and hydraulic model cross-sections of the streams. The stream centerlines are associated with the water feature (L_Wtr_Nm) that they represent. The stationing (linear distance along the stream) of each cross-section is recorded in the STREAM_STN field in the S_HydraCrossSection table, which is important to one-dimensional hydraulic models. The L_HydraXsPt table records points along each cross-section (usually from terrain takeoffs). Each point within the S_RefPoint table records the beginning location of each stationing system. The S_HydraNvalue records the roughness characterization of stream channel and overbank areas. The L_HydraModel records information about each hydraulic model, and the L_HydraEvent table records the probability of each flood event (identical to the L_HydroEvent table). The L_HydraFloodResult table records hydraulic model results (water surface elevation) for each cross-section and event combination. The S_HydraMapping table records the flood boundaries resulting from the intersection of the water surface elevation and the terrain model, and the S_BFE table records base flood elevation tick marks produced from hydraulic models. The S_HydraFlowPath and S_HydraJunction are alternative tables that store flow paths and junctions used in certain hydraulic models (other than HEC-RAS). Similarly, the S_Ovrbnkln table stores overbank lines used in certain hydraulic models.

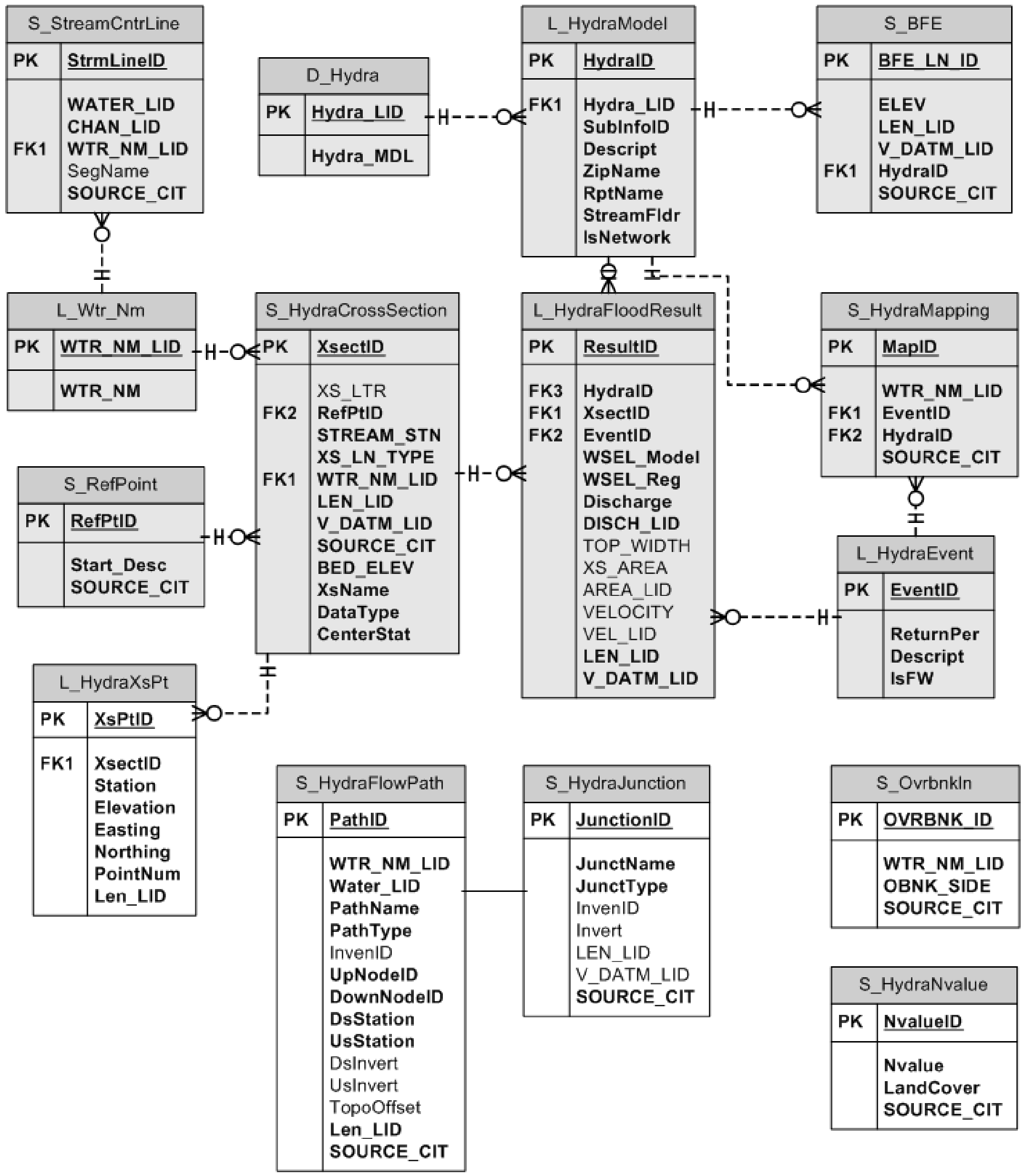


Figure 2.8 DCS Relationship Diagram for Hydraulics

2.2.3 DCS and DFIRM Discrepancies and Overlap

There are several subtle discrepancies between the DFIRM and DCS databases. For instance, the primary key field of each table in the DFIRM database is specified as a "Text" field type with a length of 11 characters, whereas the primary key field of each table in the DCS database is a long integer. This inconsistency prevents database relationships between DCS and DFIRM tables.

Another complication is that there are several DCS database tables that replace or modify DFIRM database tables. This overlap has been a source of contention between Mapping Partners and the FEMA Regional Management Center (RMC) administration coordinating the Map Modernization Program. A list of DFIRM database tables and equivalent DCS tables is presented in Table 2.8.

Table 2.8 DCS Tables Equivalent to DFIRM Tables

DFIRM Tables	DCS Tables
S_BFE	S_BFE
S_Fld_Haz_Ln	S_HydraMapping
S_Gen_Struct	S_Struc, S_ApxStr, and lookup tables
S_Nodes	S_HydroNode
S_Ovrbnkln	S_Ovrbnkln
S_Precip_Gage	S_HydroGage
S_Profil_Basln	S_HydroLink
S_Riv_Mark	S_RefPoint
S_Stn_Start	S_RefPoint
S_Subbasins	S_HydroBasin
S_Water_Gage	S_HydroGage
S_Wtr_Ln	S_StreamCntrLine
S_XS	S_HydraCrossSection
L_HydraModel	L_HydraModel
L_Hydro_Model	L_HydroModel
L_Node_Disch	L_HydroResult
L_Regression	L_HydroEquation
L_Stn_Start	S_RefPoint
L_Storm_Curve	L_HydroStormCurve
L_Storm_Info	L_HydroStormInfo
L_Subbas_Disch	L_HydroResult
L_Wtr_Nm	L_Wtr_Nm
L_XS_Ratings	L_HydraFloodResult

Chapter 3 Technology Review

As geographic information system (GIS) technology has evolved, several organizations have developed software for managing and analyzing GIS data. This software can be tailored for applications in water resources management such as hydrologic and hydraulic analysis.

3.1 GIS Software

The Environmental Systems Research Institute (ESRI®) in Redlands, CA has developed an extensive software system called ArcGIS™, and is a major provider of GIS software. Additionally, there is a community that uses open-source GIS software called GRASS which is produced by multiple agencies and individuals cooperating worldwide (http://grass.itc.it/).

The ESRI® ArcGIS™ software suite includes an application called ArcCatalog that allows users to browse GIS data in a similar way as the operation of Microsoft® File Explorer. One of the ArcGIS™ data management devices is the *personal geodatabase*, which is a Microsoft® Access database (*.mdb) customized by ESRI®. A user can create several GIS data components such as geodatabase tables, feature classes, feature datasets, relationship classes, geometric networks, raster catalogs, and raster classes.

A *geodatabase table* is an *object class* that is simply an Access table (similar to a spreadsheet; lacks geographical content). A *feature class* is an object class with geometry – a collection of geographic features with tabular attributes. A *feature dataset* is used to group feature classes like a file folder is used to group files. A *relationship class* is used to relate one feature class or geodatabase table to another. For example, a feature class may contain features of stream centerlines, and a relationship class may relate that feature class to a geodatabase table that records daily flow data.

3.2 GIS DATA MODELS IN WATER RESOURCES

Many engineering analyses are being automated through the use of computer technology and GIS software. Several GIS data models in water resources are relevant to flood hazard mapping, and related technologies have been developed specifically for improving flood hazard mapping.

Two of the most commonly used data models in water resources communities are Arc Hydro and the National Hydrography Dataset (NHD). Arc Hydro was developed by a team led by David Maidment to unite the water resources communities with a common framework for archiving and processing GIS data. The team spent several years analyzing data features common to various water resources interest groups to determine the core intersecting set of data that could be used to improve GIS archival across water resources related communities. The NHD was developed by the United States Geological Survey (USGS) and the Environmental Protection Agency (EPA).

3.2.1 Arc Hydro

The Arc Hydro geodatabase schema is organized into four feature datasets: Channel, Drainage, Hydrography, and Network, which are illustrated in Figure 3.1 (Maidment, 2002). The Channel dataset contains feature classes that describe the three-dimensional nature of stream channels (*e.g.*, profile lines, cross-sections, *etc.*). The Drainage dataset contains feature classes that describe the collection of precipitation and transform into runoff (*e.g.*, watersheds, drainage lines, drainage points, *etc.*). The Hydrography dataset contains cartographic feature classes that are used to symbolize hydrographic features (*e.g.*, waterbodies, structures, gages, *etc.*). The Network dataset includes feature classes in a geometric network useful for upstream/downstream tracing and measurements along streamlines (*e.g.*, flowlines, junctions, schematic links, schematic nodes, *etc.*). A common attribute to all features is the HydroID, which is a unique identifier across all features in the geodatabase and allows relationships and analysis processes to operate consistently, and allows any feature to be related to any other feature.

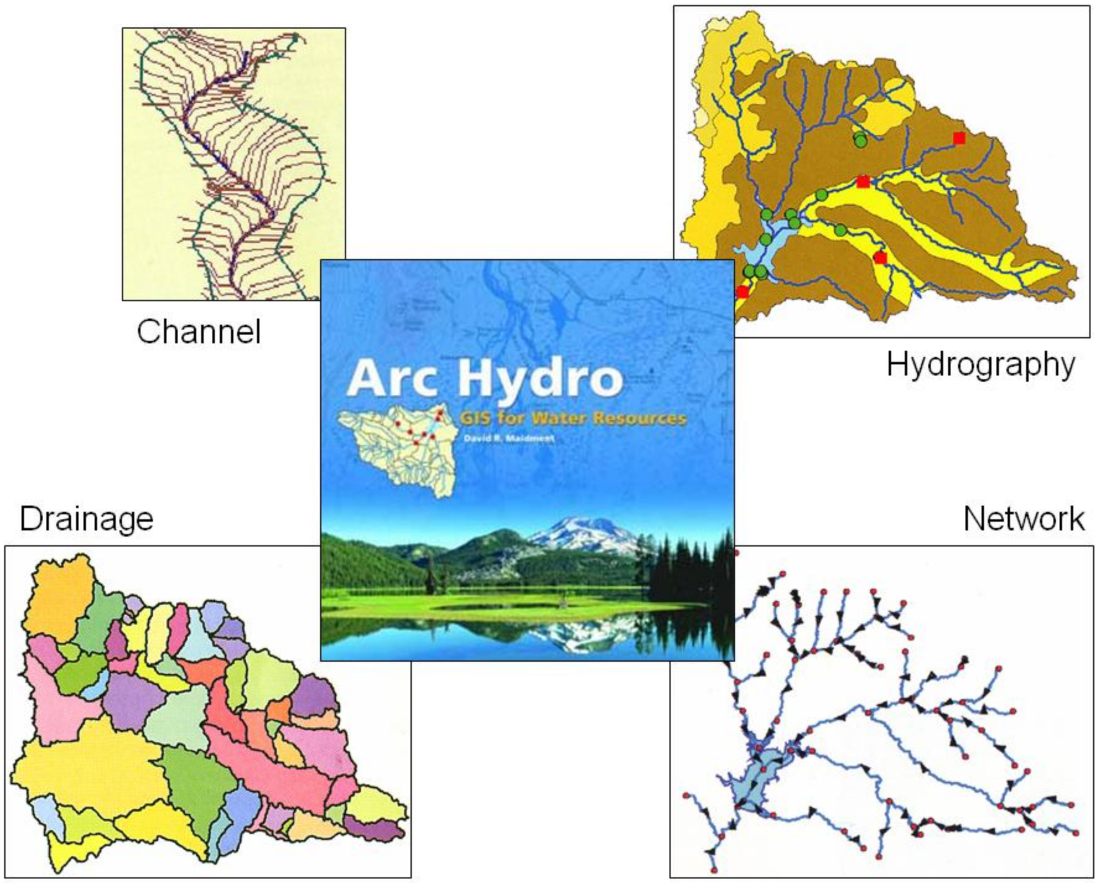


Figure 3.1 Arc Hydro Datasets

In addition to the geodatabase schema, the Arc Hydro development team created a toolbar of GIS processes for use in ArcMap. The toolbar has applications for Terrain Preprocessing, Watershed Processing, Attributing, Network analysis, and others. These functions automate preprocessing tasks of building an Arc Hydro geodatabase. The Arc Hydro toolbar is available online from the Center for Research in Water Resources (CRWR) at http://www.crwr.utexas.edu/archydrotools/tools.html. For more detailed discussions of GIS and application to hydrologic modeling, please reference *Arc Hydro: GIS for Water Resources* (Maidment, 2002) and *ArcGIS and HSPF Model Development* (Johnson *et al.*, 2005).

3.2.2 NHD

The National Hydrography Dataset (NHD) is the official United States federal network of hydrographic features, which makes it conducive to serve as a basis for many water resources communities. The NHD is also associated with the Geographic Names Information System, which is the official national repository of the names of local geographic features.

> The National Hydrography Dataset (NHD) is a comprehensive set of digital spatial data that contains information about surface water features such as lakes, ponds, streams, rivers, springs and wells. Within the NHD, surface water features are combined to form "reaches," which provide the framework for linking water-related data to the NHD surface water drainage network. These linkages enable the analysis and display of these water-related data in upstream and downstream order.
>
> The NHD is based upon the content of USGS Digital Line Graph (DLG) hydrography data integrated with reach-related information from the EPA Reach File Version 3 (RF3). The NHD supersedes DLG and RF3 by incorporating them, not by replacing them. Users of DLG or RF3 will find the National Hydrography Dataset both familiar and greatly expanded and refined.
> (USGS, 2006)

NHD data is available by hydrologic unit code (HUC), four-digit subregion at several resolutions (medium, high, and local). The medium resolution data (1:100,000 map scale) is available for the entire U.S., and the USGS is developing an improved version for the entire country known as NHD-Plus. The high resolution data (1:24,000 map scale) is available for most of the country, but local resolution data (1:5000 or better) is only available for a few HUC subregions. A sample of the NHD is shown for Fayette County, Texas is illustrated in Figure 3.2.

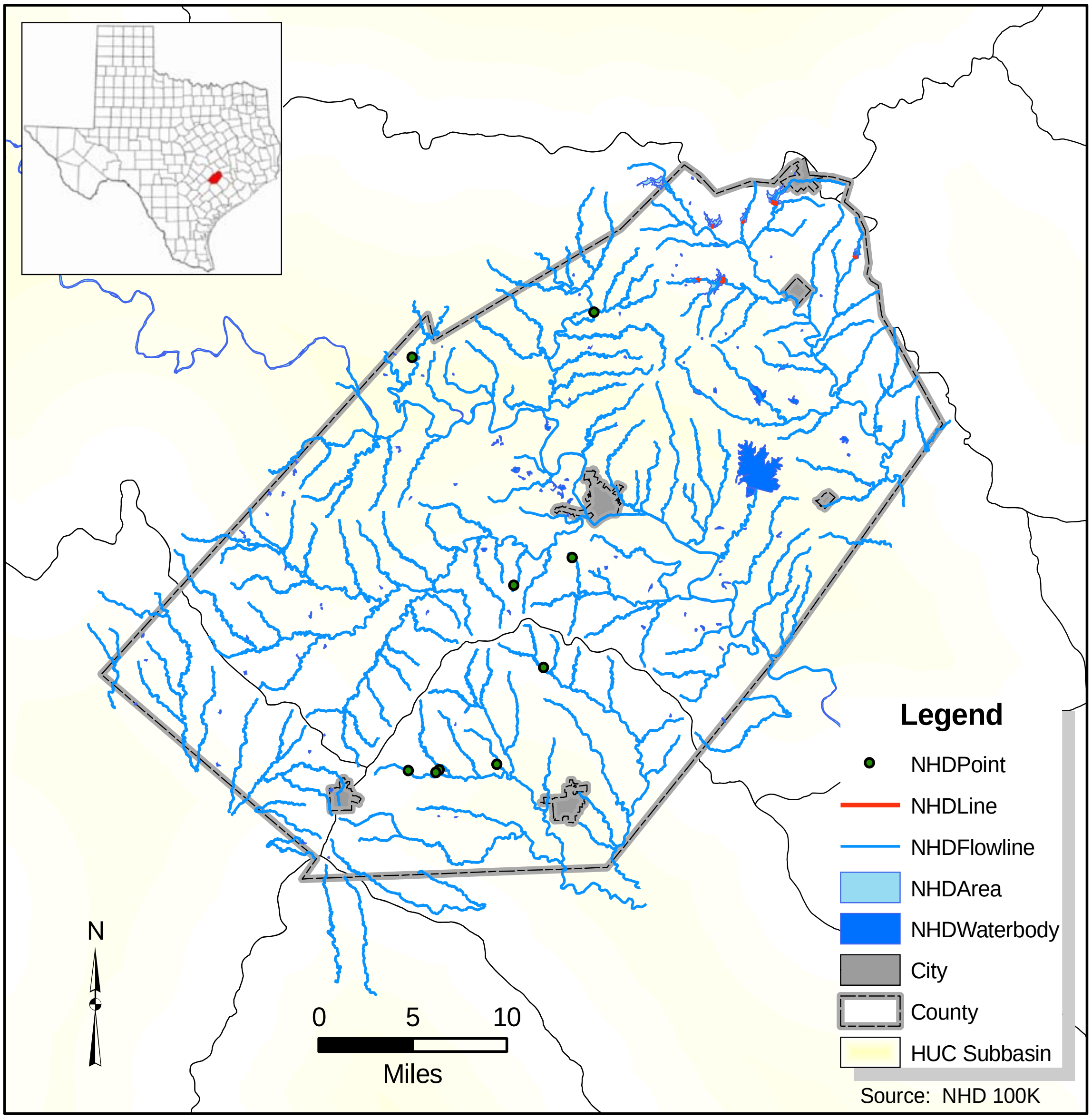


Figure 3.2 NHD 100K for Fayette County, Texas

The NHD data model was developed in an ESRI® geodatabase platform, and is similar to the Network dataset of the Arc Hydro data model. The core NHD feature classes are NHDFlowline and NHDWaterbody, which define the surface water drainage network. NHDPoint, NHDLine, and watershed and basin delineations are also contained in the NHD, which describe hydrographic features such as hydraulic structures and watersheds associated with the network.

The NHDFlowline has two fields that make it particularly valuable as a national hydrologic network. The "ComID" field is a unique integer value across all NHDFlowline features, which is essentially like the "HydroID" field of the Arc Hydro system. Additionally, the "ReachCode" field of the NHDFlowline feature class identifies each feature as a member of a "Reach," which is a collection of contiguous stream segments. The NHDFlowline network contains a measurement system that references the relative percentage measurement along the Reach, where the most upstream end point has a measurement value of 100 and the most downstream end point has a value of 0. For each NHDFlowline Reach, "From-Measure" and "To-Measure" values are associated with the upstream and downstream end points, respectively. This measurement system allows any user to universally define the precise location of any point along a Reach in the entire nation.

3.3 Custom GIS Software Applications in Flood Hazard Mapping

In addition to the hydrologic processes offered in the Arc Hydro tool suite, several private engineering companies have developed software for use in water resources analyses. WISE, RWMS, and GeoFIRM were developed for application in flood hazard mapping and management.

3.3.1 WISE®

Watershed Concepts™, a division of Hayes, Seay, Mattern & Mattern, Inc. (HSMM), is a water resources engineering firm that focuses on projects involving hydrology, hydraulics, and water quality analysis. Watershed Concepts™ has become a leader in FEMA flood hazard studies, and they developed a software package called WISE® to aid engineers in their analyses.

The Watershed Information SystEm (WISE®) is a comprehensive system to manage, access, and analyze large amounts of water resources data. WISE® is a stand-alone program that uses ESRI®'s MapObjects, ArcObjects, and SDE technology which runs on Windows platforms (2000 or XP). WISE® has ten analysis "Modules" (shown in Figure 3.3) with thematic routines for water resources engineering projects.

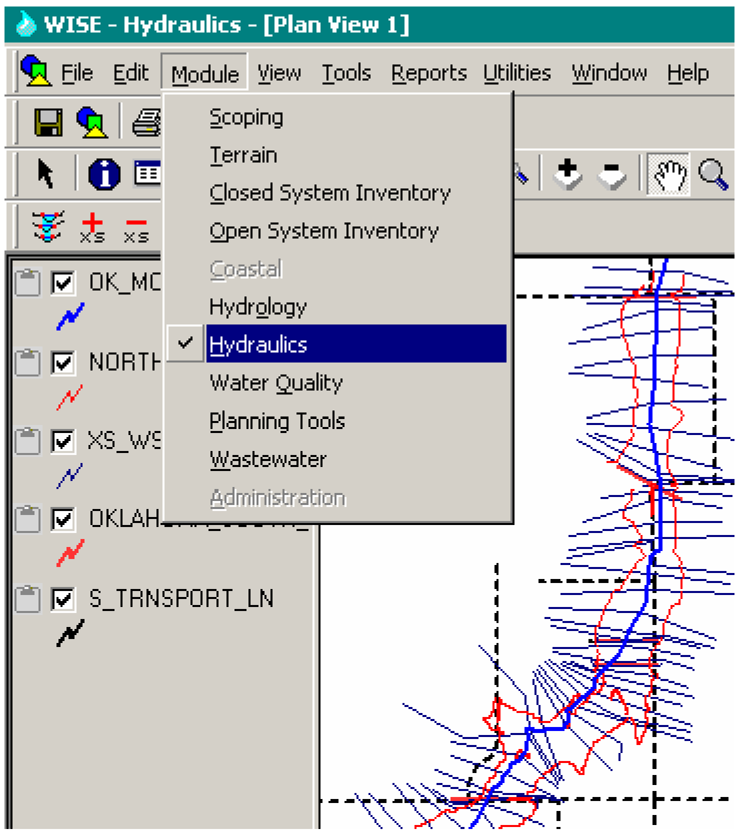


Figure 3.3 WISE® Software Modules

The WISE Terrain module allows users to define and prioritize multiple terrain model inputs, create DEM and TIN terrain models, and edit the terrain models. The Open System Inventory module has functions for importing and modifying survey information about bridges, dams, culverts, and other structures. The Hydrology module has operations for delineating a drainage system based on a terrain model, performing regression analyses in the computation of runoff discharge for locations along a stream, and creating rainfall-runoff models. The Hydraulics module has functions for automatically drawing stream cross-sections, calculating stream and cross-section takeoffs, creating hydraulic models, importing model results, and mapping flood boundaries. WISE® also has a tool that will create a DCS-compliant database from a WISE® project and related files.

Watershed Concepts™ serves as a member of the National Service Provider (NSP) of the Map Modernization Program, which is the engineering liaison between FEMA and the Flood Hazard Mapping Partners. Since Watershed Concepts™ is part of the NSP, they offer WISE® software for free use to the Flood Hazard Mapping Partners.

3.3.2 RWMS

The Regional Watershed Management System (RWMS) was developed by PBS&J and San Antonio River Authority (SARA) in cooperation with the Bexar Regional Watershed Management Coalition (BRWMC). The RWMS is an enterprise geodatabase with a web portal that serves as a central repository of watershed management data and models and allows BRWMC partners to "manage, maintain and efficiently distribute modeling and support information through an enterprise GIS framework" (McArthur *et al.*, 2006).

The engineering workflow involving the RWMS involves several steps and is illustrated in Figure 3.4. The workflow process begins when an engineering contractor is hired to study a portion of the BRWM region. Through the interactive Web Portal, the engineer defines the study region and "checks out" a copy of hydrologic and hydraulic models for that study region, whereby the RWMS processes the request and emails a zip

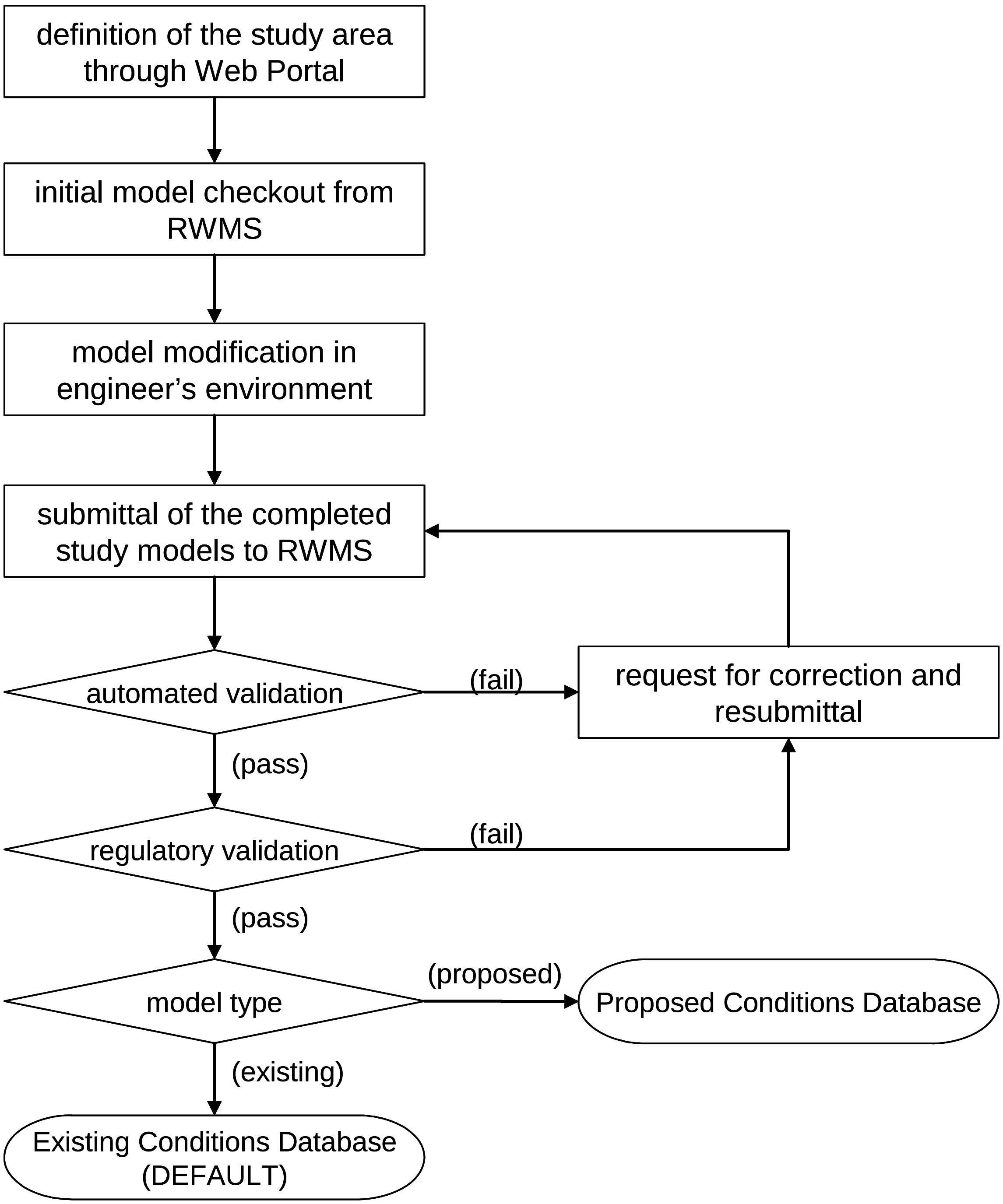


Figure 3.4 RWMS Workflow Diagram

file containing HEC-HMS and HEC-RAS models of the selected study region, and the engineer performs the study (usually by modifying the received HEC-HMS and HEC-RAS models). Upon completion of the project, the engineer submits the models, and the RWMS performs an automatic validation to determine if and what model components have been modified. If a submitted model is found to be incomplete, or if it does not meet several engineering business rules, then notification is sent to the engineer that the submittal failed validation, and the engineer must correct the problem and resubmit the model. After a model passes the initial model validation, it is sent to the appropriate regulatory agency for further inspection. If the submitted model is accepted, then it is ingested into one of the two master databases: existing conditions (default), or proposed conditions that represent future development. (McArthur *et al.*, 2006)

The RWMS geodatabase structure is designed to store every model parameter from a HEC-HMS and HEC-RAS model, so the developers created custom “Interface Data Models” that ingest data from the native model files. The BRWM partners are interested in expanding the RWMS to store other model types, such as water quality. This expansion would support Total Maximum Daily Load (TMDL) studies with Hydrological Simulation Program – FORTRAN (HSPF) modeling. Also, future development will add functionality to RWMS to support FEMA flood mapping and flood forecasting.

3.3.3 Other Relevant Software

HEC-GeoHMS and HEC-GeoRAS are ArcGIS toolsets that were developed by ESRI® and the Hydrologic Engineering Center (HEC) of the United States Army Corps of Engineers (USACE) to aid in hydrologic and hydraulic model development. The HEC-GeoHMS toolbar allows the user to analyze digital elevation models (DEMs), create geographic components (basins, streams, junctions, *etc.*) for a HEC-HMS model, and compute basin curve numbers from State Soil Geographic (STATSGO) and Soil Survey Geographic (SSURGO) databases. The HEC-GeoRAS toolbar allows a user to create HEC-RAS input files describing stream channels and cross-sections developed from a digital terrain model (DTM) and process HEC-RAS output files that describe water surface elevation and velocity.

The Watershed Modeling System (WMS) is GIS based software produced by Environmental Modeling Systems, Inc. (EMS-i) that includes functions such as: automated watershed delineation, stochastic modeling, two-dimensional (distributed) hydrologic/hydraulic modeling, and floodplain mapping.

> The Watershed Modeling System (WMS) is a comprehensive graphical modeling environment for all phases of watershed hydrology and hydraulics. WMS includes powerful tools to automate modeling processes such as automated basin delineation, geometric parameter calculations, GIS overlay computations (CN, rainfall depth, roughness coefficients, etc.), cross-section extraction from terrain data, and many more! With the release of WMS 7, the software now supports hydrologic modeling with HEC-1 (HEC-HMS), TR-20, TR-55, Rational Method, NFF, MODRAT, and HSPF. Hydraulic models supported include HEC-RAS, SMPDBK, and CE QUAL W2. 2D integrated hydrology (including channel hydraulics and groundwater interaction) can now be modeled with GSSHA. (Environmental Modeling Systems, Inc., 2006)

Other similar hydrologic and hydraulic software includes GeoFIRM, which is produced by Dewberry® (Dewberry, 2006), and a suite of FEMA-approved storm related products by Haestad Methods (Bentley Systems, Inc., 2006).

Chapter 4 Methodology

4.1 Design Approach

FEMA administrative personnel, as well as Mapping Partners, desire a database that resolves the conflict between the DFIRM and DCS database structures, implements technological advancement, and contributes valuable data to the generic water resources community. Therefore, the objective of this research project is to design a Flood Study Geodatabase (FSG) that (1) merges the DFIRM and DCS databases into a single database, (2) converts the existing relational database into a true geodatabase technology, and (3) relates FEMA Flood Hazard Mapping data to the National Hydrography Dataset.

4.1.1 Merge the DFIRM & DCS Databases

In order to create a single database from the DFIRM and DCS databases, it is necessary to review and compare the information contained in each table in each database. Since the DCS was developed after the DFIRM, the designers modeled the DCS after the DFIRM and created several DCS tables similar to tables in the DFIRM. The DCS designers took the opportunity to improve the "copied" DFIRM tables in the DCS.

Through this review, it is apparent that there are two situations in which there is a table in the DCS database that is similar to a DFIRM database table. First, if a DCS table has the same name and fields as a DFIRM table, then the DCS table is considered to supersede the DFIRM table. Second, if a DCS table is determined to represent the same information as a DFIRM table but has a different name, then the fields of each table are compared to determine if the DCS table supersedes the DFIRM table, or if information from the DFIRM table should be consolidated into the DCS table.

4.1.2 Normalization - Traditional Relational Database versus Geodatabase

One of the fundamental differences between the design of a traditional relational database and the design of a geodatabase is the use of normalization, which is a process of efficiently organizing a database to eliminate redundancy. Traditional relational databases are normalized. However, in personal geodatabases, tables may be normalized, but feature classes are *un-normalized*.

Simple "flat table" databases are not normalized and have a few tables with many duplicated entries. A simplified example of a flat table database that records stream network information is illustrated in Figure 4.1.

Flat_Streams : Table

Segment	StreamName	US_seg_1	US_seg_2	DS_seg	US_STATION	DS_STATION
1	Buckners Creek	2	291		3431	0
2	Buckners Creek	3	273	1	15917	3431
3	Buckners Creek	4	768	2	27551	15917
4	Buckners Creek	5	481	3	36564	27551
5	Buckners Creek	6	263	4	41780	36564
6	Buckners Creek	7	256	5	55696	41780
7	Buckners Creek	8	362	6	58893	55696
8	Buckners Creek	9	251	7	62874	58893
9	Buckners Creek			8	70127	62874

Record: 10 of 10

Figure 4.1 Flat Table Database Example – Stream Lines

In relational databases, data entry duplication is eliminated by normalizing the flat table into multiple tables that are related by a key field. In an example of a *normalized* relational database from Figure 4.1, the stream name is only entered once in the Stream table and related to the Segments table through the Customer "key" fields (shown in Figure 4.2). An advantage of implementing a relational database design is reducing storage space requirements because data is not duplicated, but extensive relational databases are characterized by a myriad of small tables and many relationships.

Normalized_Reaches...

Reach	StreamName
1	Buckners Creek
2	Dry Creek
3	Brushy Creek

Record: 4

Normalized_Segments : Table

Segment	Reach	US_seg_1	US_seg_2	DS_seg	US_STATION	DS_STATION
1	1	2	291		3431	0
2	1	3	273	1	15917	3431
3	1	4	768	2	27551	15917
4	1	5	481	3	36564	27551
5	1	6	263	4	41780	36564
6	1	7	256	5	55696	41780
7	1	8	362	6	58893	55696
8	1	9	251	7	62874	58893
9	1			8	70127	62874

Record: 10 of 10

Figure 4.2 Relational Database Example – Stream Network

In most database designs, it is beneficial to implement a normalized relational database because the tabular data describes business transactions, product inventory, or some other abstract information. In computer user interfaces (such as database forms) using relational databases, it may be desirable to visualize data with graphical descriptors (e.g., icons or photographs). Thus, a traditional *relational database* is a set of tabular data that may have graphical descriptors.

A *geodatabase*, however, is a set of geometric features with tabular attributes; that is, a geodatabase records physical objects and events that have geometry (shape), geographical location (as shown in Figure 4.3) with tabular descriptive information. As a result, it is *not always* desirable to normalize data in geodatabases because of the interactive nature of GIS tools. For instance, while interactively viewing a hydrographic dataset in an ArcMap session, it is convenient for the user to see the stream name as a dynamic label that is queried from the stream name field in the stream network feature class. Otherwise, if the tables were normalized, all features (stream segments) with the same stream name (say, "Buckners Creek") would have the same foreign key to a stream name table, and the user would be required to identify the feature of interest, record the foreign key, and look up the corresponding stream name in the Reach table. Therefore, since the FIS is a mapping process, the geodatabase is the most suitable data repository.

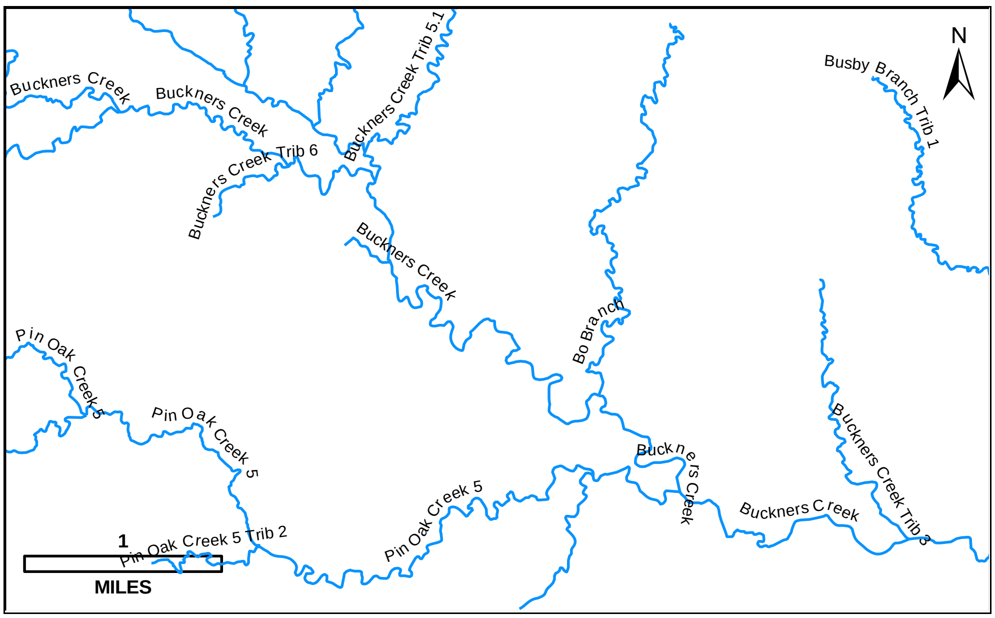


Figure 4.3 Geodatabase Example –Stream Geographic Network

4.1.3 Geodatabase Feature Classes, Tables, and Coded Value Domains

The DFIRM and DCS databases specify spatial "S_*" tables, lookup "L_*" tables, and domain "D_*" tables. The spatial tables include a "geometry" file in addition to the table, but the lookup and domain tables are simply tables of information. These three types of tables should be converted to ESRI geodatabase feature classes, tables, and coded value domains, respectively. Also, some lookup tables should be un-normalized onto related feature classes per reasons aforementioned.

An advantage of converting the spatial tables and their respective geometry tables to feature classes is that it consolidates the two sets of information into a more manageable system within a common framework (*i.e.*, a feature class is a single table within a geodatabase). Additionally, the feature classes should be united within a feature dataset, which allows topological rules to be constructed between feature classes. For example, through the use of topological rules, the geodatabase will enforce that the boundary lines of political areas represented in the S_Pol_Ln table be *coincident* with the edges of a polygon representation of the same area in the S_Pol_Ar table.

At first glance, it may appear redundant to store both line and polygon features representing the same boundary, because a polygon feature is the higher order representation that essentially contains the duplicated line features in its boundary. However, it is desirable to store both polygon *and* line representations in the database when one or more edges of a polygon must be cartographically symbolized differently than other edges of the same polygon. For example, when displaying a county edge that is coincident with a state border, it may be desirable to cartographically symbolize the coincident edge as a state border, and the remaining county edges should be symbolized as a county boundary. By storing polygon and line features, users can employ the advantages of spatial analysis with polygons, cartographic shading with polygons, and multiple, variant-edge symbologies with lines.

The advantages of converting the domain tables to coded value domains in the geodatabase are twofold. First, coded value domains in the ESRI® geodatabase environment can be used to preemptively restrict field entries. The DFIRM and DCS database systems rely on production quality control measures to ensure that data entry is performed properly. Coded value domains ensure a higher level of data reliability. The second advantage is more aesthetic; coded value domains are stored internally in the geodatabase structure. This storage method intuitively separates tables into two groups - those which can be edited by the user, and those which cannot; as opposed to the DFIRM and DCS database structure which has all of the domain tables existing in the same echelon with spatial and lookup tables.

4.1.4 Geodatabase Optimization through Field Types

In addition to the aforementioned objectives, it is necessary to also consider issues such as database storage efficiency, intuitive nature or user-friendliness, and thematic data groups and process workflow. It is important that field types are properly assigned to minimize the amount of storage space required to record the data. For instance, if a field is going to record the length in feet of a stream, then it should be a numeric type instead of a text type; and if a field should store the number of culvert barrels in a bridge, the field type should be a short integer instead of a float or long integer. Also, an important database performance tool is called "field indexing" which improves the query speed of values in a particular field. Integer fields are indexed faster and more reliably than text fields, which may include "padded blanks" (another reason why integer fields are preferred). Table 4.1 records the ArcGIS™ field types and corresponding restrictions and storage space required; these parameters must be considered in order to optimize the performance of the geodatabase.

Table 4.1 ArcGIS™ Field Types and Storage Parameters

Field Type	Specific range, length, or format	Bytes	Applications
Short integer	-32,768 to 32,767	2	numeric values without fractional values; coded values
Long integer	-2,147,483,648 to 2,147,483,647	4	numeric values without fractional values within specific range
Float (Single precision number)	-3.4E38 to 1.2E38	4	numeric values with fractional values within specific range
Double (Double precision number)	-2.2E308 to 1.8E308	8	numeric values with fractional values within specific range
Date	mm/dd/yyyy hh:mm:ss	8	date and/or time
Text	up to 64,000 characters	1 / char.	names or other textual qualities
BLOB	varies	varies	images or other multimedia
GUID	36 characters	38	customized applications requiring global identifiers

There are many fields in DFIRM database tables that are specified as text field type with a length of 11 characters, which means that 11 Bytes of storage space are allocated for each table entry. If these fields are only storing integer values, then they should be an integer field type. A long integer field type can store up to a nine-digit integer (over two billion positive values). In the case of foreign key fields that reference a domain table, there are a small number of valid entries; so the field type should be a short integer (over 32,000 positive values) which is 18% of the storage space required for the text field. The domain codes specified in the DFIRM and DCS databases do not exceed four digits, so the short integer field type is acceptable.

4.1.5 Relate to Generic Water Resources Community

Because of the extensive spatial coverage and ubiquity of the High Resolution version of the National Hydrography Dataset (NHD), the NHD should be the standard stream network referencing system for the FEMA Map Modernization program. As the Network dataset within the Arc Hydro data model provides a common framework to which all other features can be referenced, so the NHD provides a means of relating Map Modernization data to an official national stream network. This network relationship is particularly advantageous because, in most cases, the High Resolution NHDFlowline network is more spatially extensive than the streamlines modeled by Mapping Partners in a Flood Mapping Project. Thus, Map Modernization streamline features can be related (in most cases) to an NHDFlowline Reach. Also, since most Flood Mapping Projects are performed on a countywide basis, the network nature of the streamlines in the DCS database is only effective within a given county because there is no mandate for edge-matching them at county boundaries, largely because Flood Hazard Projects in adjacent counties are mostly performed by different Mapping Partners. By referencing the NHD, the Map Modernization data would exist in a national network without employing a tedious edge-matching process.

4.2 RESULTS

4.2.1 Flood Study Geodatabase (FSG) Structure

The Flood Study Geodatabase (FSG) schema utilizes five geodatabase components: feature datasets, feature classes, tables, coded value domains, and relationships. From the existing 32 DFIRM *spatial* tables and 32 DCS *spatial* tables, there are 56 FSG *feature classes* listed in Figure 4.4 that contain spatial elements and are grouped into six feature datasets (Coastal, DFIRM, Hydraulics, Hydrology, Survey, and Terrain). Of the existing 19 DFIRM *lookup* tables and 41 DCS *lookup* tables, there are 37 FSG *geodatabase tables* that record non spatial information about the flood hazard study and are listed in Figure 4.5. Also, the DFIRM and DCS *domain* tables are incorporated into the FSG as *coded value domains* with the addition of several new coded value domains, resulting in 56 coded value domains that control data entries for certain fields in the Flood Study Geodatabase, and these domains are listed in Table 4.2. The FSG schema is much slimmer than the existing DFIRM and DCS schemas; through the use of ArcCatalog, the FSG user browses through 93 feature classes and tables instead of 169 spatial, lookup, and domain tables. A geodatabase diagram illustrating the connectivity of feature classes and tables within the FSG is provided in Appendix B. Attributes of these geodatabase feature classes, tables, coded value domains, and relationship classes are included in Appendix C.

Figure 4.4 Flood Study Geodatabase - Feature Datasets and Classes

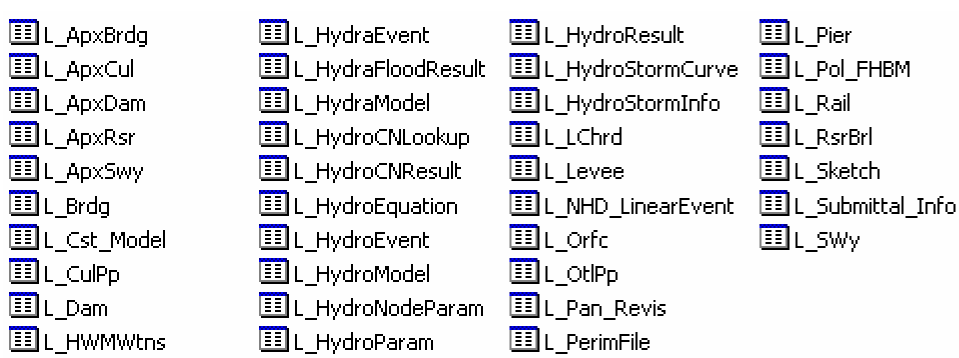


Figure 4.5 Flood Study Geodatabase - Tables

Table 4.2 Flood Study Geodatabase - Coded Value Domains

Domain Name	Description
D_AbtTyp	Type of Abutment
D_Area_Units	Area Unit
D_Boolean_TF	TRUE-FALSE
D_Boolean_YN	YES-NO
D_CBRS_Typ	Type of Coastal Barrier Resources System
D_Chan_Rep	Type of Channel Representation
D_ClsTyp	Type of Closure
D_DamTyp	Type of Dam
D_DatTyp	Type of Cross-Sections
D_Dimensionless	Dimensionless Unit
D_Discharge_Units	Discharge Units
D_Eros_Meth	Type of Erosion Method in Coastal Transect
D_Floodway	Type of Floodway
D_Frequency	Event Frequency
D_Gage	Type of Gage
D_H_Datum	Type of Horizontal Datum
D_HWLnTp	Type of High Water Line
D_Hydra	Type of Hydraulic Model
D_Hydro	Type of Hydrologic Model
D_Label_Typ	Type of Map Label
D_Length_Units	Length Unit
D_LevTyp	Type of Levee
D_Ln_Typ	Type of Map Line
D_LOMC_Status	LOMC Status
D_Method	Type of Coastal Transect Elevation Method
D_MtlTyp	Type of Material
D_Nm_Typ	Type of Road Name
D_Nodes	Type of Node
D_Panel_Typ	Type of FIRM Panel
D_PpTyp	Type of Pipe
D_Rd_Status	Road Status
D_Runup_Mdl	Type of Runup Model
D_Scale	Map Scale
D_ShpTyp	Type of Shape
D_Shr_Rough	Shoreline Roughness
D_Shr_Typ	Shoreline
D_State	USA State/Territory Name
D_Storms	Type of Storm
D_Struct_Typ	Type of Structure
D_StudyDetail	Type of FHM Study
D_Surge_Mdl	Type of Surge Model
D_SwyTyp	Type of Spillway
D_Temp_Units	Temperature Units
D_Time_Units	Time Units
D_Trans_Typ	Type of Transportation Line

Table 4.2 Flood Study Geodatabase - Coded Value Domains (continued)

Domain Name	Description
D_Unit_Type	Type of Unit
D_V_Datum	Vertical Datum
D_Velocity_Unit	Velocity Unit
D_Volume_Units	Volume Unit
D_VZone	Type of Coastal V Zone Extent Methodology
D_Water_Typ	Type of Water Line
D_Wave_Mdl	Type of Waveheight Model
D_XS_Ln_TYP	Type of DFIRM Cross-Section Line
D_Zone	Type of Flood Zone
D_XS_Ln_TYP	DFIRM Cross-Section Line Type
D_Zone	Flood Zone

4.2.2 Consolidated DFIRM and DCS Tables

Most DFIRM and DCS tables are adopted into the FSG without modifications (other than changing field types and associating coded value domains). However, several DFIRM tables are superseded by DCS tables, and a few additional tables are consolidated or un-normalized in the FSG, as listed in Table 4.3.

One of the modifications to the DFIRM and DCS is the un-normalization of the L_Wtr_Nm table onto the S_StreamCntrLine feature class in the FSG. In the DFIRM and DCS, the L_Wtr_Nm table behaves as a user-defined “domain” table to create a consistent list of water feature names, but this L_Wtr_Nm normalized system makes it tedious to investigate stream names from the spatial features, as discussed earlier in this chapter. Furthermore, the stream centerline is the backbone of an entire Flood Hazard Mapping Project, as it most precisely represents the physical entities that are being analyzed in a project. Thus, in the FSG, the geographic name is stored in a field in the S_StreamCntrLine feature class. Also, the S_StreamCntrLine feature class is a Polyline ZM (Z – elevation values for each vertex; M – continuous linear measurement along the line) to record the three-dimensional geometry of stream centerlines, which are only represented by single lines and are required to match endpoint-to-endpoint. The S_Wtr_Ln feature class is retained in the FSG for cartographic purposes only.

Table 4.3 DFIRM and DCS Tables Consolidated in the FSG

DFIRM	DCS	FSG
-	S_HydraCrossSection, L_HydraXsPt	S_HydraCrossSection
S_Subbasins	S_HydroBasin	S_HydroBasin
S_Precip_Gage, S_Water_Gage	S_HydroGage	S_HydroGage
S_Profil_Baslin	S_HydroLink	S_HydroLink
S_Nodes	S_HydroNode	S_HydroNode
S_Ovrbnkln	S_Ovrbnkln	S_Ovrbnkln
L_Media	L_SXSPht, L_HWMPht, L_ApxPht, L_StrPht	S_Photo
S_Pol_Ar, L_Comm_Info	-	S_Pol_Ar
S_Riv_Mark, S_Stn_Start, L_Stn_Start	S_RefPoint	S_RefPoint
L_Wtr_Nm	S_StreamCntrLine	S_StreamCntrLine
S_Gen_Struct	S_Struc	S_Struc
-	S_SXS, L_SXS	S_SXS
S_Wtr_Ar, L_Wtr_Nm	-	S_Wtr_Ar
S_Wtr_Ln, L_Wtr_Nm	-	S_Wtr_Ln
L_XS_Ratings	L_HydraFloodResult	L_HydraFloodResult
L_Hydra_Model	L_HydraModel	L_HydraModel
L_Regression	L_HydroEquation	L_HydroEquation
L_Hydro_Model	L_HydroModel	L_HydroModel
L_Subbas_Disch, L_Node_Disch	L_HydroResult	L_HydroResult
L_Storm_Curve	L_HydroStormCurve	L_HydroStormCurve
L_Storm_Info	L_HydroStormInfo	L_HydroStormInfo
-	L_Sketch, L_SXSSkt, L_HWMSkt, L_StrSkt	L_Sketch
Study_Info, L_Case_Info, L_Aux_Data	L_Submittal_Info	L_Submittal_Info

In the DCS, the three-dimensional geometry of hydraulic cross-sections is stored in two datasets: 1) the planimetric S_HydraCrossSection line table and 2) elevation points along those cross-section lines in the L_HydraXsPt table. These two tables are consolidated in the FSG S_HydraCrossSection feature class, which is polyline ZM.

4.2.3 Additional Modifications

Several DFIRM and DCS tables are included with modifications in the Flood Study Geodatabase (FSG). First, the name of DCS S_BFE spatial table is changed to

S_HydraBFE in the FSG to distinguish the base flood elevation (BFE) markers that are automatically produced by mapping software from the actual BFE lines that appear on the DFIRM and are recorded in the S_BFE feature class. Second, letters of map revision (LOMRs) describe stream segments that have been restudied independently from an entire countywide study, and a LOMR is documented by a polygon that includes the flood zone spatial extent that is modified by the restudy. This polygon representation is rather ambiguous, as it is sometimes a freehand drawing of the affected study "boundary". A more precise method of documenting LOMRs would be to trace the centerline of the stream segment that is restudied. Thus, the FSG S_LOMR feature class is specified as a polyline instead of a polygon.

Similarly, some letters of map change (LOMCs) represent a specific site that has been surveyed to confirm elevations above (out of) a flood hazard area. These LOMCs are recorded in the DFIRM L_MT1_LOMC lookup table, but should record the location of the points that are excluded from the flood hazard area. Thus, the FSG S_MT1_LOMC is a point feature class.

The purpose of the DCS D_HydroParam domain table is to form a uniform list of parameters and their respective units used in hydrologic regression equations. However, this creates an exception to the "domain" concept, which is to be restricted from modification by the Mapping Partner. Thus, the D_HydroParam table is improved in the FSG L_HydroParam table by implementing subtypes on the UnitType field. The subtypes allow a user to choose which unit type (area, discharge, length, time, velocity, volume, or dimensionless) represents the regression parameter, and the UnitID field is automatically controlled by the geodatabase to restrict the user's entry to that particular unit type. For instance, if the user is adding a parameter for the drainage area of a basin, then he or she would select the "Area" UnitType, and the UnitID field would automatically be restricted to “ACRES, HECTARES, SQUARE FEET, SQUARE METERS, SQUARE YARDS, or SQUARE MILES.”

The added geodatabase table, L_NHD_LinearEvent, relates the FSG data to the NHD, and consequently, to the rest of the water resources community. The L_NHD_LinearEvent table has four fields that connect the FSG to the NHD: StrmLineID, NHD_Reach, F_Measure, and Tom. The StrmLineID records the unique identifier of the S_StreamCntrLine feature class, and that stream segment’s corresponding NHDFlowline ReachCode is stored in the NHD_Reach field. The F_Measure and T_Measure fields are populated with the "From" and "To" measurements of the NHDFlowline reach that describe the extent of the S_StreamCntrLine feature on the NHDFlowline reach.

4.2.4 Arc Hydro Similarities

Much of the water resources community is interested in relating GIS data to the Arc Hydro data model; and subsets of the FSG schema can, in fact, be directly correlated to each of the Arc Hydro feature datasets (Channel, Drainage, Hydrography, and Network). A summary of the correlation between the Arc Hydro and FSG feature classes is presented in Figure 4.6.

The S_StreamCntrLine feature class records the three-dimensional geometry of stream centerlines in the FSG and is directly mapped to the ProfileLine feature class within the Channel dataset. The S_SXS and S_HydraCrossSection feature classes record three-dimensional geometry (transverse to the streamline) that describes the bathymetry of the stream channel and overbank, and these feature classes are directly mapped to the CrossSection feature class within the Channel dataset. Furthermore, the station measuring system along the S_StreamCntrLine is similar to the measurement system along the ProfileLine, which records the location of each cross-section along the stream.

The core structure of the hydrology section of the FSG is very similar to the Drainage dataset of the Arc Hydro framework. Each S_HydroBasin feature representing a drainage collection area has a one-to-one foreign key to an S_HydroNode feature, which represents the outflow point of that S_HydroBasin feature. These feature classes are analogous to the Watershed and DrainagePoint feature classes within the Drainage dataset. Also, the terrain derived feature class, S_StreamsDEM, matches the Arc Hydro DrainageLine feature class.

One of the most prominent FSG feature classes, S_Fld_Haz_Ar, matches directly with the HydroArea feature class in the Hydrography dataset of Arc Hydro. The FSG S_Wtr_Ln and S_Wtr_Ar feature classes map to the HydroLine and Waterbody feature classes in the Hydrography dataset of Arc Hydro. The Arc Hydro feature class, HydroResponseUnit, describes areas of uniform precipitation-runoff transformation, which corresponds to the FSG S_HydroLandUse and S_HydroSoil feature classes. The FSG S_HydroGage feature class includes precipitation and streamflow gages, which corresponds to the Arc Hydro MonitoringPoint feature class. In the Arc Hydro data model, hydraulic structures are recorded by the Structures point feature class; whereas, in the FSG, detailed structures and approximate structures are recorded in the S_Struc and S_ApxStr feature classes.

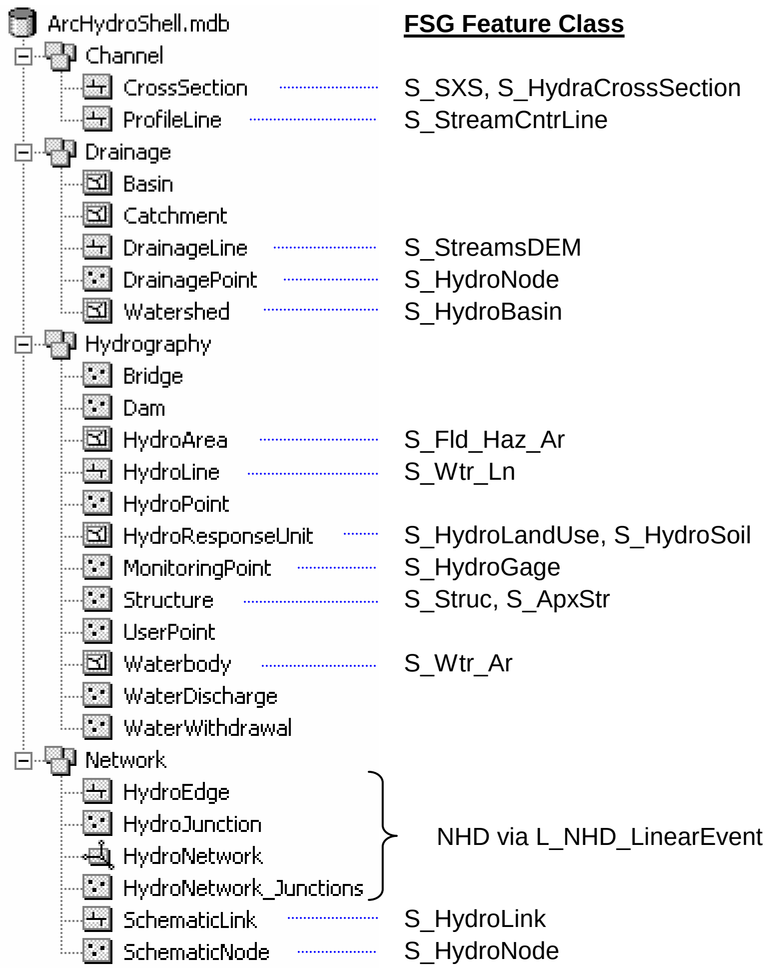


Figure 4.6 Arc Hydro and FSG Feature Class Correlation

Each S_HydroLink feature representing hydrologic connectivity is related to an S_HydroNode feature, which behaves identically to the SchematicLink and SchematicNode interaction. Furthermore, the FSG can embrace the NHD geometric-network functionality through the use of the L_NHD_LinearEvent table, and the NHD can serve the purpose for the FSG that the geometric-network dataset serves for the Arc Hydro framework. That is, every FSG feature's stream network position can be referenced to the national standard, the NHD.

In addition to feature class correlation, there is one other significant comparison between Arc Hydro and the FSG – the HydroID. In the Arc Hydro data model, each feature is identified by a HydroID (long integer) that is unique across the *entire geodatabase*, which can be assigned by a tool in the Arc Hydro toolbar. The HydroID field serves as the primary key for all relationships involving feature classes. This singular unique-identification system simplifies the management of the geodatabase by requiring the maintenance of only one number generator. The FSG has a static, long integer field that is, at a minimum, unique across *each feature class*, though a user could implement the HydroID concept by making them unique across the entire geodatabase. When considering a Mapping Partner submitting data in geodatabase form, the HydroID concept may not provide any significant advantages, because it is a single-use geodatabase (*i.e.*, the Mapping Partner creates a geodatabase to submit data and is never forced to update or maintain it). However, when considering a state or federal repository that constantly ingests new data submittals and updates existing data, the efficient HydroID management concept is crucial. In this repository case, every primary key field (Long Integer) could simply be renamed to “HydroID,” and the Arc Hydro tools could be used to assign unique values. Alternatively, in the national repository case, every primary key field could be replaced by a text field, where the unique identification is a concatenation of the community FIPS code, the FEMA Case number or six digit date, a unique three digit number for each feature class or table, and the submitted primary key value. This text code would be globally unique and would contain useful regional, temporal, and typical categorization metadata for each data entry.

Chapter 5 Procedure of Application

Considering the widespread use of ESRI® software and products, the Flood Study Geodatabase was designed as an ESRI® geodatabase. When designing an ESRI® personal geodatabase, it is possible to use the standard user interfaces to create feature classes, tables, coded value domains, and relationships; however, these user interfaces are tedious because they require the user to manually transcribe all field names and use pull-down menus to choose field types. The user interfaces are especially frustrating if the user wishes to make modifications or correct a typographical error made in the creation process. For this reason, an alternative method for creating an ESRI® geodatabase was implemented without using the standard user interfaces.

5.1 ESRI® ARCCATALOG™ - GEODATABASE DESIGNER 2 TOOLBAR

One such alternative method is to use the ESRI® Geodatabase Designer 2 toolbar, which allows the user to create an XML document of an existing geodatabase or create a geodatabase from an existing XML document. This functionality allows a designer the flexibility to create and modify an XML document until the designer is ready to convert it to an ESRI® geodatabase. An illustration of the Geodatabase Designer 2 toolbar is presented in Figure 5.1. The toolbar does not come with the standard installation of ArcMap, but software to install the Geodatabase Designer 2 toolbar is available online for free download at the ESRI® Support website (http://support.esri.com/).

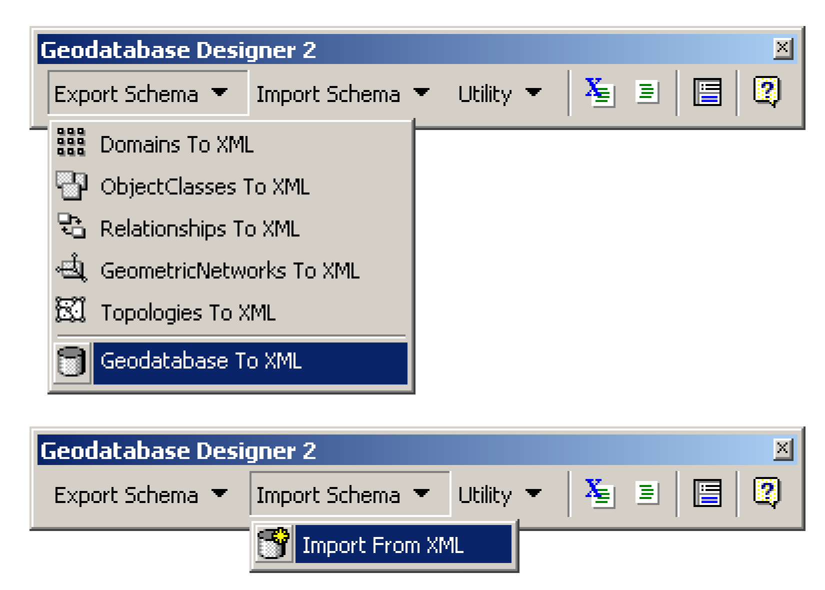


Figure 5.1 Geodatabase Designer 2 Toolbar Functionality

Extensible Markup Language (XML) is simply an ASCII text file with user-defined formatting similar to HyperText Markup Language (HTML). XML is useful for storing hierarchical data in a platform/software independent format. XML is extremely versatile because it is programmatically simple to write and read, and it is readable by most web browsers.

From an existing geodatabase, the Geodatabase Designer 2 toolbar creates an XML document (Version 1.0) that is divided into five sections: metadata; domains; feature datasets and feature classes; stand-alone object classes (i.e., geodatabase tables); relationships; and geometric networks. A sample XML document was created from an existing Arc Hydro geodatabase (using the "Geodatabase To XML" tool) to serve as a template in the development of an Excel spreadsheet and VBA script that creates such an XML document. This Excel and VBA script system was used to create an XML document of the Flood Study Geodatabase schema. A flow chart of the use of the Excel spreadsheet, VBA script, XML file, Geodatabase Designer 2 toolbar, and Geodatabase is shown in Figure 5.2.

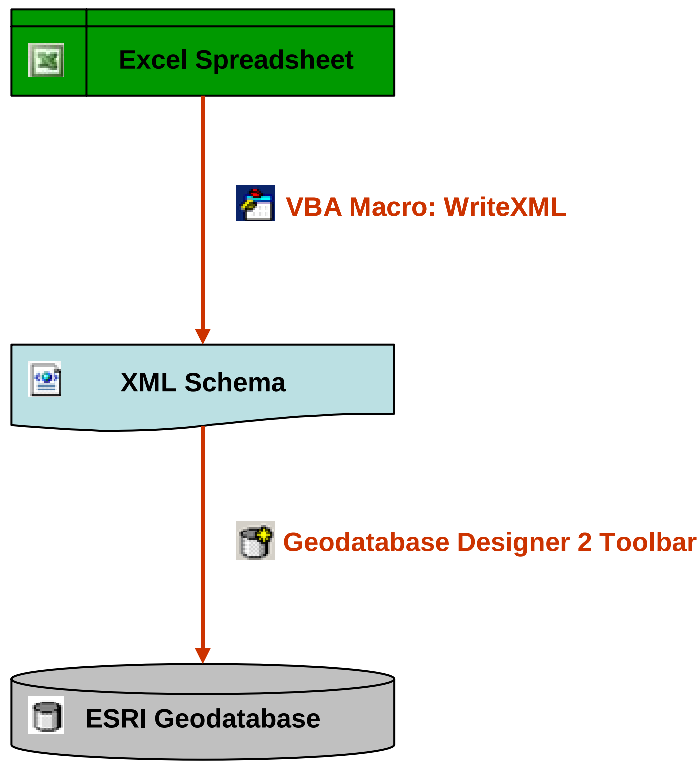


Figure 5.2 Geodatabase Schema Creation Flowchart

5.2 MICROSOFT® EXCEL SPREADSHEET AND VBA SCRIPT "WRITEXML"

A Microsoft® Excel spreadsheet was used to document the attribute tables in Appendices L and N (DFIRM and DCS, respectively) by creating a worksheet for each Appendix that included the entire set of attribute tables ("D_*", "L_*", and "S_*").

From these two worksheets, four additional worksheets (coded value domains, feature datasets and feature classes, stand-alone object classes, and relationships) were created to organize the schema details in a similar fashion as the Geodatabase Designer 2 XML document.

A diagram of the XML geodatabase schema hierarchy (on which the Excel hierarchy is based) is presented in Figure 5.3, and the list of attributes for each hierarchal level is presented in Table 5.1. Within each coded value domain, there may be multiple code-description pairs, as illustrated in Figure 5.4 (column headings are grouped by color according to the hierarchal level they describe). Similarly, an example of the Excel hierarchy for feature classes is shown in Figure 5.5, and an example of the Excel hierarchy for object classes (i.e., geodatabase tables) is shown in Figure 5.6. Also, an example of the Excel worksheet for relationship classes is shown in Figure 5.7.

Microsoft® Visual Basic for Application (VBA) is a Basic programming language that allows the programmer to utilize properties and methods specific to Microsoft applications such as Excel. A custom VBA script was written to translate the database attributes contained in the Excel spreadsheet to an ESRI® Geodatabase Designer 2 compatible XML document. Specifically, the VBA script "WriteXML" reads the Excel spreadsheet (looping through each hierarchal level in the FSG structure) and writes an XML file describing the FSG geodatabase. A copy of the WriteXML script is included in Appendix A of this thesis. The resulting XML file can be imported using the "Import from XML" to create an empty ESRI® geodatabase. A sample of XML code is presented in Figure 5.8 that describes the same L_HydroParam object class (table) that appears in Figure 5.6. An example of the L_HydroParam object class as it appears in the Flood Study Geodatabase is presented in Figure 5.9.

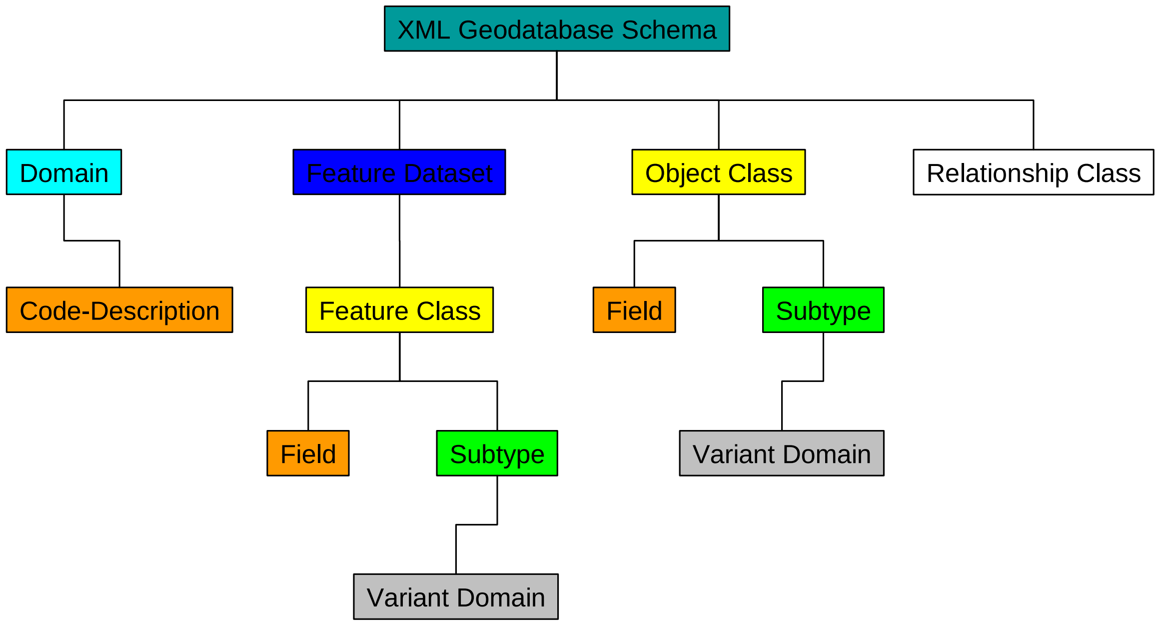
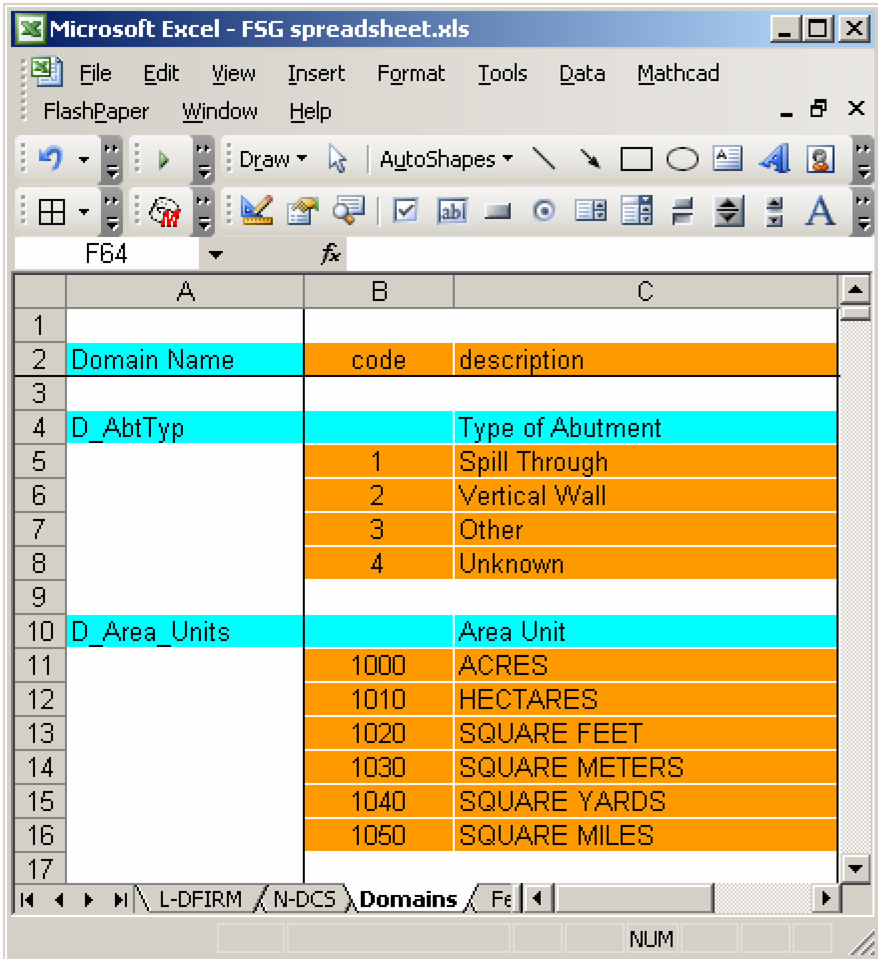


Figure 5.3 Geodatabase Designer 2 XML Hierarchy

Table 5.1 FSG Spreadsheet - Hierarchal Level Attributes

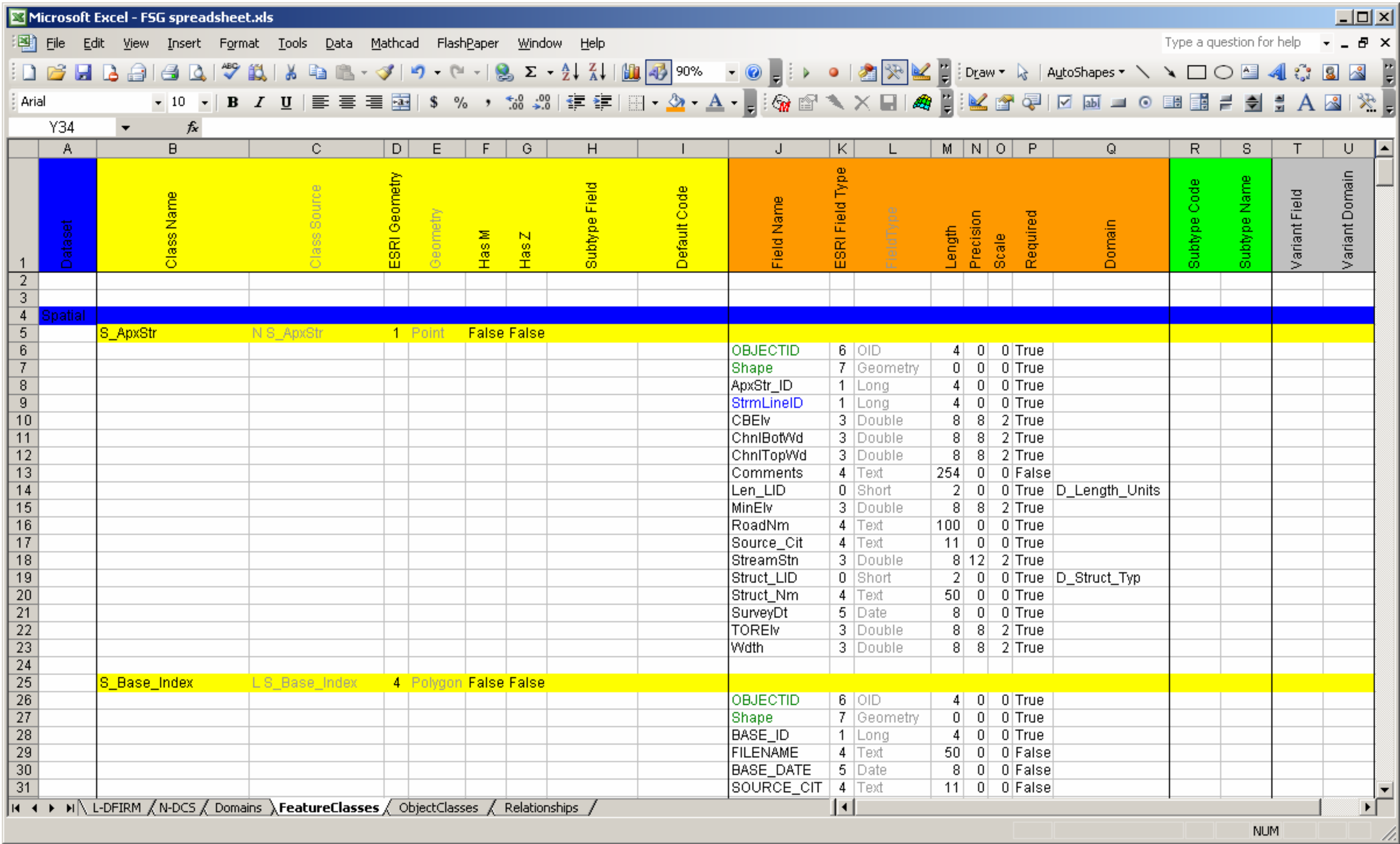
Domains	Feature Classes	Object Classes	Relationships
Domain Name	Dataset	Class Name	Relationship Name
code	Class Name	Class Source*	Origin
description	Class Source *	Subtype Field	Primary
	ESRI Geometry	Default Code	Destination
	Geometry *	Field Name	Foreign
	Has M	ESRI Field Type	ESRI Cardinality
	Has Z	FieldType*	Cardinality *
	Subtype Field	Length	
	Default Code	Precision	
	Field Name	Scale	
	ESRI Field Type	Required	
	FieldType *	Domain	
	Length	Subtype Code	
	Precision	Subtype Name	
	Scale	Variant Field	
	Required	Variant Domain	
	Domain		
	Subtype Code		
	Subtype Name		
	Field Name		
	Field Domain		

* not required; recorded for readibility only



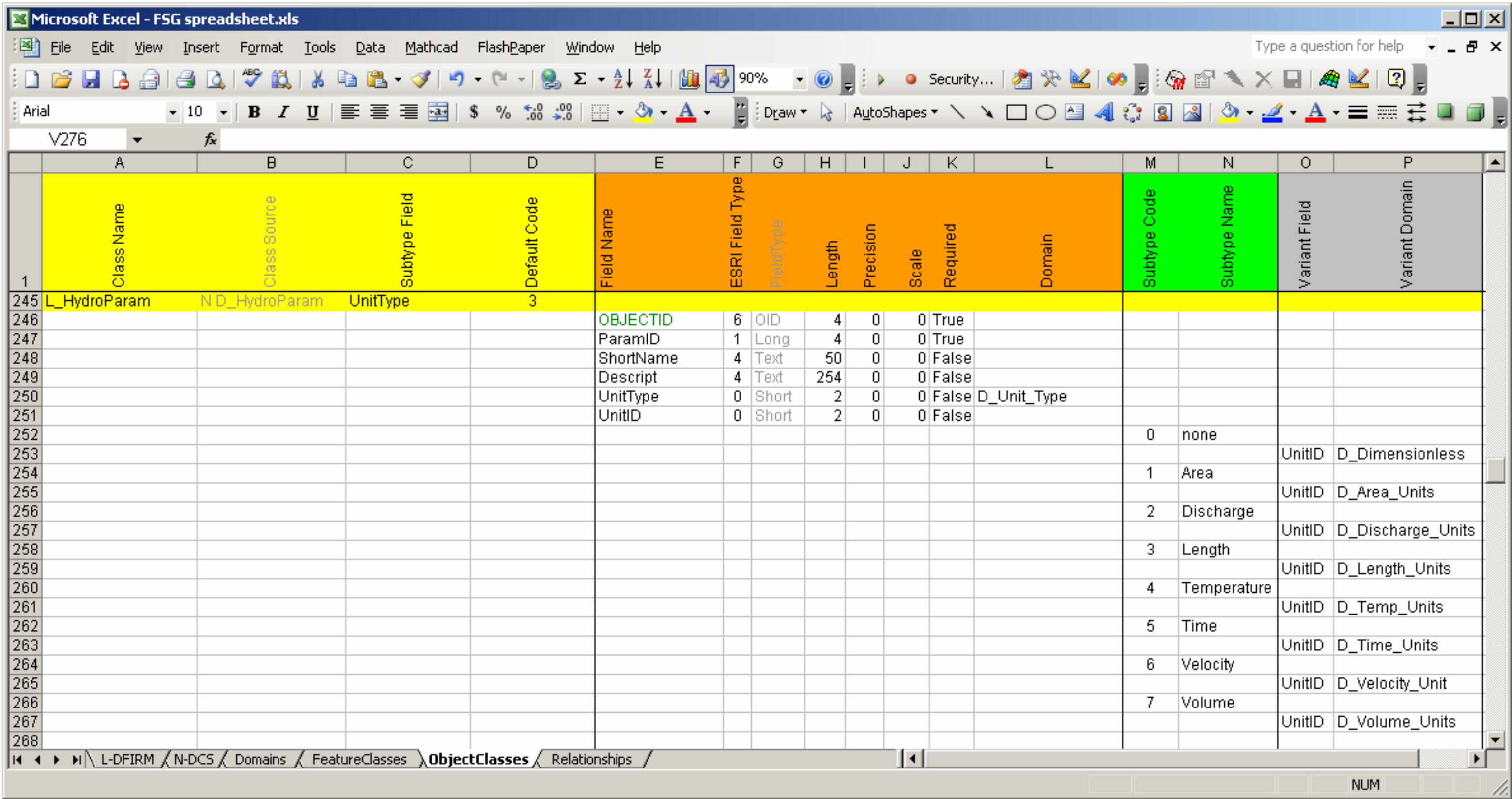
	A	B	C
1			
2	Domain Name	code	description
3			
4	D_AbtTyp		Type of Abutment
5		1	Spill Through
6		2	Vertical Wall
7		3	Other
8		4	Unknown
9			
10	D_Area_Units		Area Unit
11		1000	ACRES
12		1010	HECTARES
13		1020	SQUARE FEET
14		1030	SQUARE METERS
15		1040	SQUARE YARDS
16		1050	SQUARE MILES
17			

Figure 5.4 FSG Spreadsheet Hierarchy for Coded Value Domains



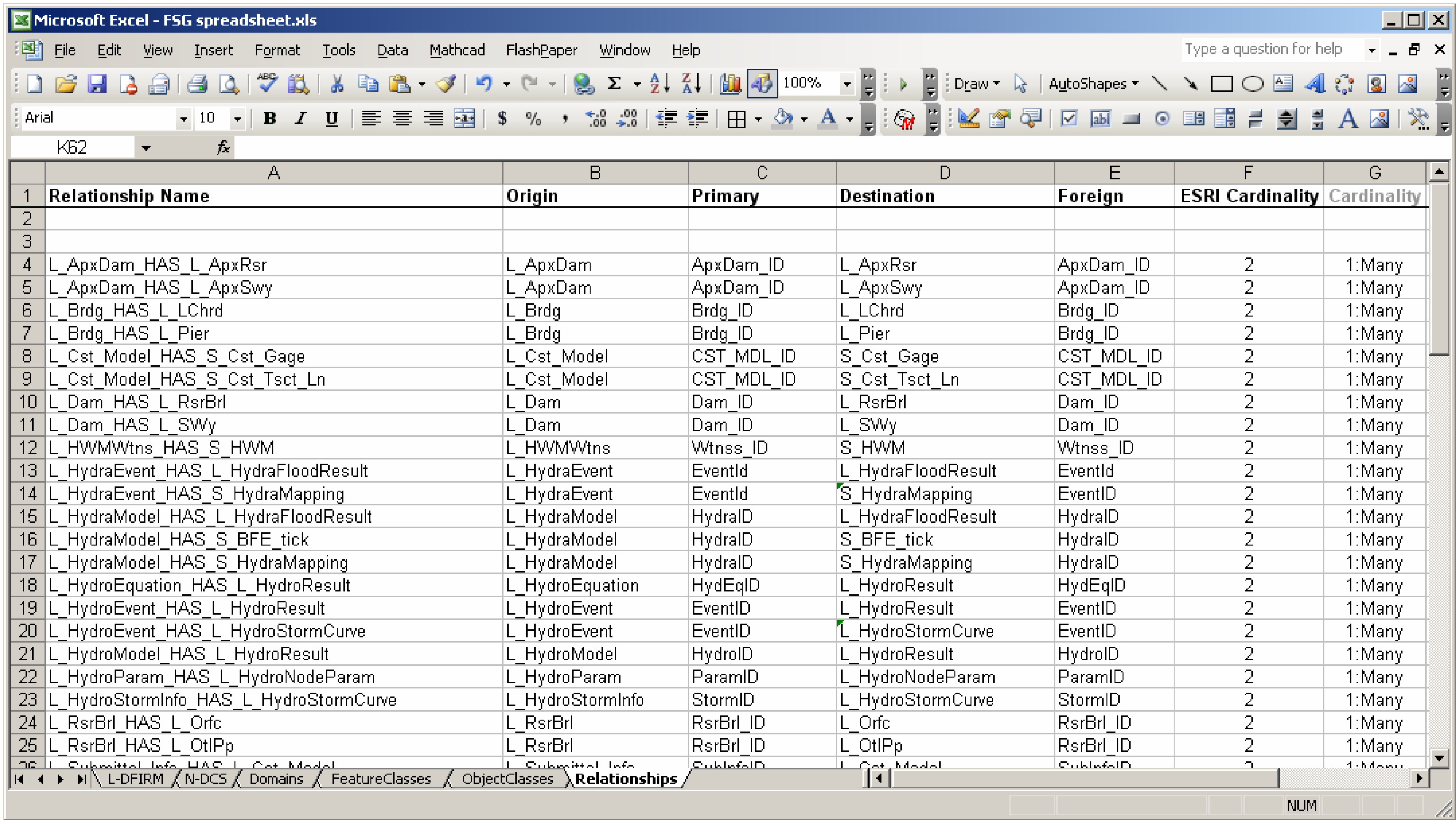
	Dataset	Class Name	Class Source	ESRI Geometry	Geometry	Has M	Has Z	Subtype Field	Default Code	Field Name	ESRI Field Type	FieldType	Length	Precision	Scale	Required	Domain	Subtype Code	Subtype Name	Variant Field	Variant Domain
2																					
3																					
4	Spatial																				
5		S_ApxStr	N S_ApxStr	1	Point	False	False														
6										OBJECTID	6	OID	4	0	0	True					
7										Shape	7	Geometry	0	0	0	True					
8										ApxStr_ID	1	Long	4	0	0	True					
9										StrmLineID	1	Long	4	0	0	True					
10										CBElv	3	Double	8	8	2	True					
11										ChnlBotWd	3	Double	8	8	2	True					
12										ChnlTopWd	3	Double	8	8	2	True					
13										Comments	4	Text	254	0	0	False					
14										Len_LID	0	Short	2	0	0	True	D_Length_Units				
15										MinElv	3	Double	8	8	2	True					
16										RoadNm	4	Text	100	0	0	True					
17										Source_Cit	4	Text	11	0	0	True					
18										StreamStn	3	Double	8	12	2	True					
19										Struct_LID	0	Short	2	0	0	True	D_Struct_Typ				
20										Struct_Nm	4	Text	50	0	0	True					
21										SurveyDt	5	Date	8	0	0	True					
22										TOREIv	3	Double	8	8	2	True					
23										Wdth	3	Double	8	8	2	True					
24																					
25		S_Base_Index	L S_Base_Index	4	Polygon	False	False														
26										OBJECTID	6	OID	4	0	0	True					
27										Shape	7	Geometry	0	0	0	True					
28										BASE_ID	1	Long	4	0	0	True					
29										FILENAME	4	Text	50	0	0	False					
30										BASE_DATE	5	Date	8	0	0	False					
31										SOURCE_CIT	4	Text	11	0	0	False					

Figure 5.5 FSG Spreadsheet Hierarchy for Feature Dataset and Feature Classes


Microsoft Excel - FSG spreadsheet.xls

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Class Name	Class Source	Subtype Field	Default Code	Field Name	ESRI Field Type	FieldType	Length	Precision	Scale	Required	Domain	Subtype Code	Subtype Name	Variant Field	Variant Domain
245	L_HydroParam	N D_HydroParam	UnitType	3												
246					OBJECTID	6	OID	4	0	0	True					
247					ParamID	1	Long	4	0	0	True					
248					ShortName	4	Text	50	0	0	False					
249					Descript	4	Text	254	0	0	False					
250					UnitType	0	Short	2	0	0	False	D_Unit_Type				
251					UnitID	0	Short	2	0	0	False					
252													0	none		
253															UnitID	D_Dimensionless
254													1	Area		
255															UnitID	D_Area_Units
256													2	Discharge		
257															UnitID	D_Discharge_Units
258													3	Length		
259															UnitID	D_Length_Units
260													4	Temperature		
261															UnitID	D_Temp_Units
262													5	Time		
263															UnitID	D_Time_Units
264													6	Velocity		
265															UnitID	D_Velocity_Unit
266													7	Volume		
267															UnitID	D_Volume_Units
268																

Figure 5.6 FSG Spreadsheet Hierarchy for Object Classes (Geodatabase Tables)


Microsoft Excel - FSG spreadsheet.xls

	A	B	C	D	E	F	G
1	**Relationship Name**	**Origin**	**Primary**	**Destination**	**Foreign**	**ESRI Cardinality**	**Cardinality**
2							
3							
4	L_ApxDam_HAS_L_ApxRsr	L_ApxDam	ApxDam_ID	L_ApxRsr	ApxDam_ID	2	1:Many
5	L_ApxDam_HAS_L_ApxSwy	L_ApxDam	ApxDam_ID	L_ApxSwy	ApxDam_ID	2	1:Many
6	L_Brdg_HAS_L_LChrd	L_Brdg	Brdg_ID	L_LChrd	Brdg_ID	2	1:Many
7	L_Brdg_HAS_L_Pier	L_Brdg	Brdg_ID	L_Pier	Brdg_ID	2	1:Many
8	L_Cst_Model_HAS_S_Cst_Gage	L_Cst_Model	CST_MDL_ID	S_Cst_Gage	CST_MDL_ID	2	1:Many
9	L_Cst_Model_HAS_S_Cst_Tsct_Ln	L_Cst_Model	CST_MDL_ID	S_Cst_Tsct_Ln	CST_MDL_ID	2	1:Many
10	L_Dam_HAS_L_RsrBrl	L_Dam	Dam_ID	L_RsrBrl	Dam_ID	2	1:Many
11	L_Dam_HAS_L_SWy	L_Dam	Dam_ID	L_SWy	Dam_ID	2	1:Many
12	L_HWMWtns_HAS_S_HWM	L_HWMWtns	Wtnss_ID	S_HWM	Wtnss_ID	2	1:Many
13	L_HydraEvent_HAS_L_HydraFloodResult	L_HydraEvent	EventId	L_HydraFloodResult	EventId	2	1:Many
14	L_HydraEvent_HAS_S_HydraMapping	L_HydraEvent	EventId	S_HydraMapping	EventID	2	1:Many
15	L_HydraModel_HAS_L_HydraFloodResult	L_HydraModel	HydraID	L_HydraFloodResult	HydraID	2	1:Many
16	L_HydraModel_HAS_S_BFE_tick	L_HydraModel	HydraID	S_BFE_tick	HydraID	2	1:Many
17	L_HydraModel_HAS_S_HydraMapping	L_HydraModel	HydraID	S_HydraMapping	HydraID	2	1:Many
18	L_HydroEquation_HAS_L_HydroResult	L_HydroEquation	HydEqID	L_HydroResult	HydEqID	2	1:Many
19	L_HydroEvent_HAS_L_HydroResult	L_HydroEvent	EventID	L_HydroResult	EventID	2	1:Many
20	L_HydroEvent_HAS_L_HydroStormCurve	L_HydroEvent	EventID	L_HydroStormCurve	EventID	2	1:Many
21	L_HydroModel_HAS_L_HydroResult	L_HydroModel	HydroID	L_HydroResult	HydroID	2	1:Many
22	L_HydroParam_HAS_L_HydroNodeParam	L_HydroParam	ParamID	L_HydroNodeParam	ParamID	2	1:Many
23	L_HydroStormInfo_HAS_L_HydroStormCurve	L_HydroStormInfo	StormID	L_HydroStormCurve	StormID	2	1:Many
24	L_RsrBrl_HAS_L_Orfc	L_RsrBrl	RsrBrl_ID	L_Orfc	RsrBrl_ID	2	1:Many
25	L_RsrBrl_HAS_L_OtlPp	L_RsrBrl	RsrBrl_ID	L_OtlPp	RsrBrl_ID	2	1:Many
26	L_Submittal_Info_HAS_L_Cst_Model	L_Submittal_Info	SubInfoID	L_Cst_Model	SubInfoID	2	1:Many

L-DFIRM / N-DCS / Domains / FeatureClasses / ObjectClasses / Relationships

Figure 5.7 FSG Spreadsheet Hierarchy for Relationship Classes

_FSG.xml - Notepad

File Edit Format View Help

```xml
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	esriDatasetType="10" esriFeatureType="" shapeField="" subtypeField="UnitType" defaultSubtypeCode="3"
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		scale="0" domainFixed="False" editable="False" isNullable="False" modelName="OBJECTID"/>
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		</subtype>
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		</subtype>
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		</subtype>
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		<subtype name="Length" code="3">
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		</subtype>
		<subtype name="Temperature" code="4">
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		</subtype>
		<subtype name="Time" code="5">
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		</subtype>
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		</subtype>
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		</index>
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			<field name="OBJECTID"/>
		</index>
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			<field name="Shape"/>
		</index>
	</objectClass>
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Figure 5.8 Sample XML Schema Code for L_HydroParam Object Class (Table)

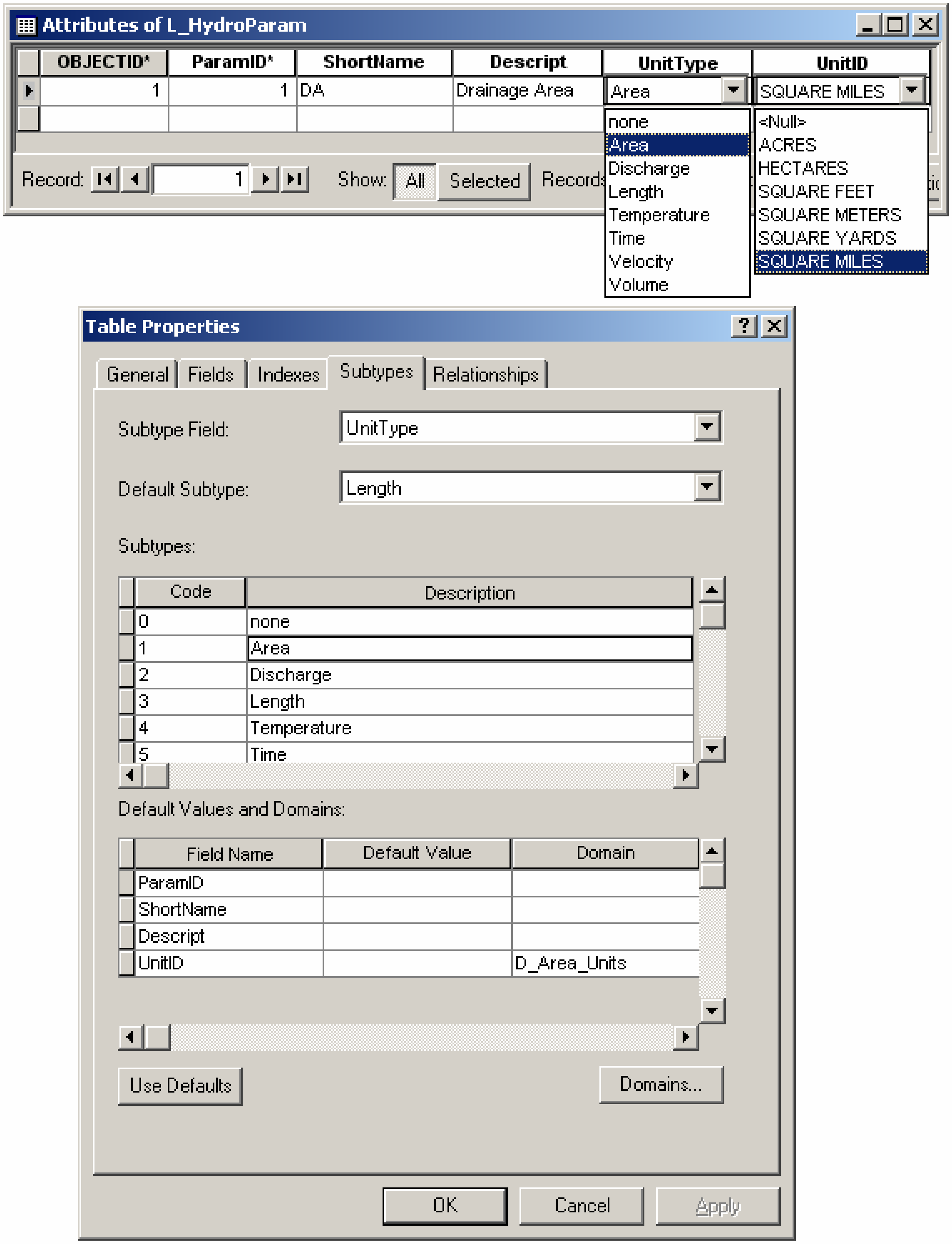

Figure 5.9 FSG Example of L_HydroParam Object Class (Table)

Chapter 6 Case Study: Fayette County, Texas

Fayette County is southeast of Austin, Texas, and downstream from Austin along the Colorado River, as illustrated in Figure 6.1. A FEMA Flood Insurance Study (FIS) of Fayette County was performed in 2005 by Watershed Concepts of Austin, Texas and Espey Consultants, Inc. of Austin, Texas. Approximately 880 stream miles were studied by approximate methods; 16 stream miles were studied by enhanced approximate methods; 5 stream miles were studied by detailed methods; and 49 stream miles were redelineated or digitally converted.

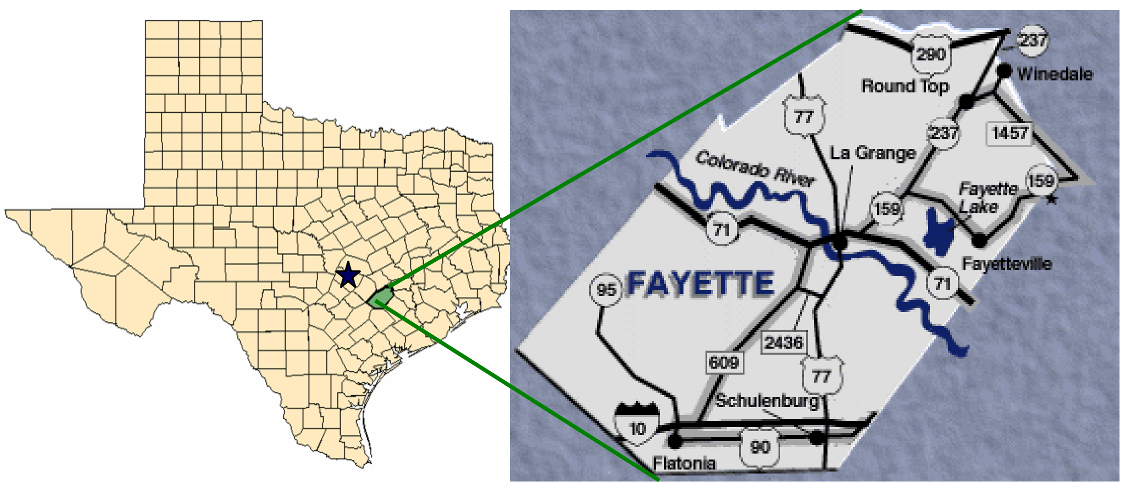

Figure 6.1 Location of Fayette County, Texas

During the project, GIS data were produced that support terrain, hydrologic, and hydraulic models for Fayette County. In addition, GIS data were produced to represent base map and FIRM (cartographic) features. The following sections illustrate the core Flood Study Geodatabase features from the Fayette County project.

6.1 TERRAIN

A terrain model of Fayette County was produced by compiling multiple terrain data sources: 1) Contour lines from USGS 7.5 Minute Topographic maps within Fayette County, 2) Contour lines with 2-feet intervals from the Lower Colorado River Authority (LCRA) along the Colorado River, and 3) USGS 10-meter and 30-meter Digital Elevation Models (DEMs). These data were prioritized according to resolution and assembled into a single terrain model using the Terrain Module in the WISE® software described in Chapter 3. One of the most common ways of representing a terrain model is with elevation contours, which records paths of constant elevation and is stored in the FSG S_Contour feature class. An example is shown in Figure 6.2 of contour lines with 2-feet intervals in Fayette County that were produced from the terrain model using the WISE® software tools.

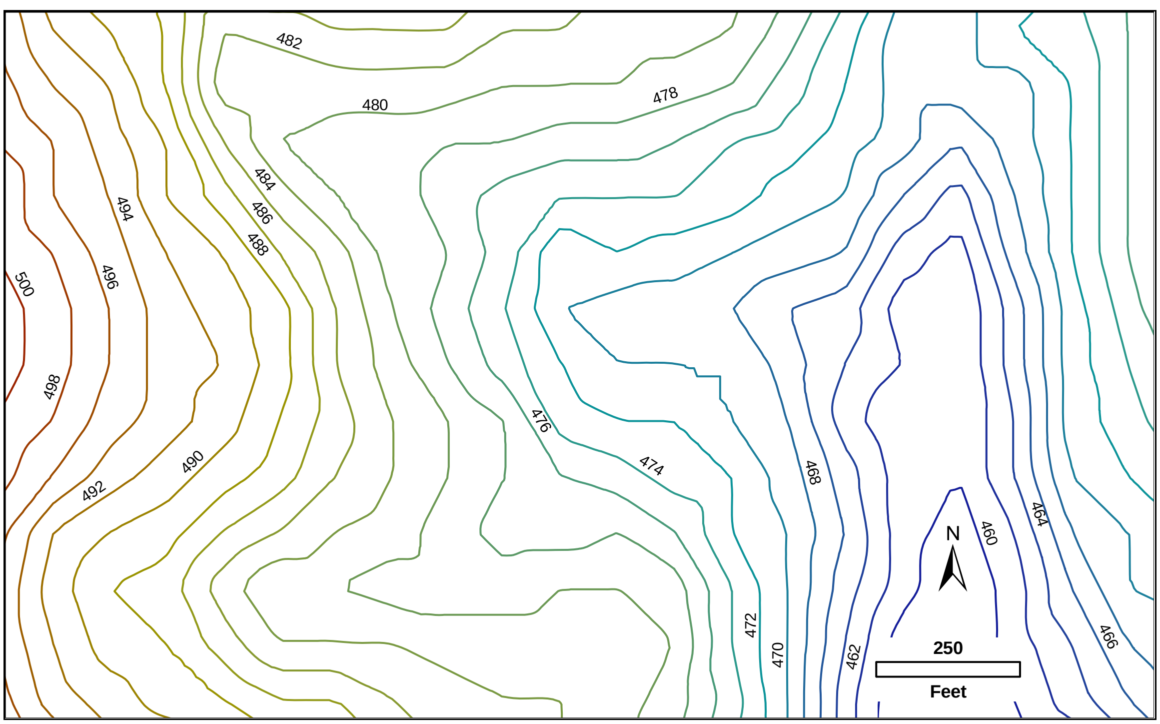

Figure 6.2 Fayette County Sample Terrain Contours (2-feet interval)

Another common terrain model representation is the digital elevation model (DEM), which is a raster (grid) visualization of a terrain model where each cell records the average elevation of its spatial extent. Simple arithmetic algorithms can be performed cell-by-cell on a DEM to compute flow direction, flow accumulation, and streams. DEM derived streams are stored in the S_StreamsDEM feature class. A sample DEM raster with 50-feet cells in Fayette County is presented in Figure 6.3 that was produced using the WISE® software tools.

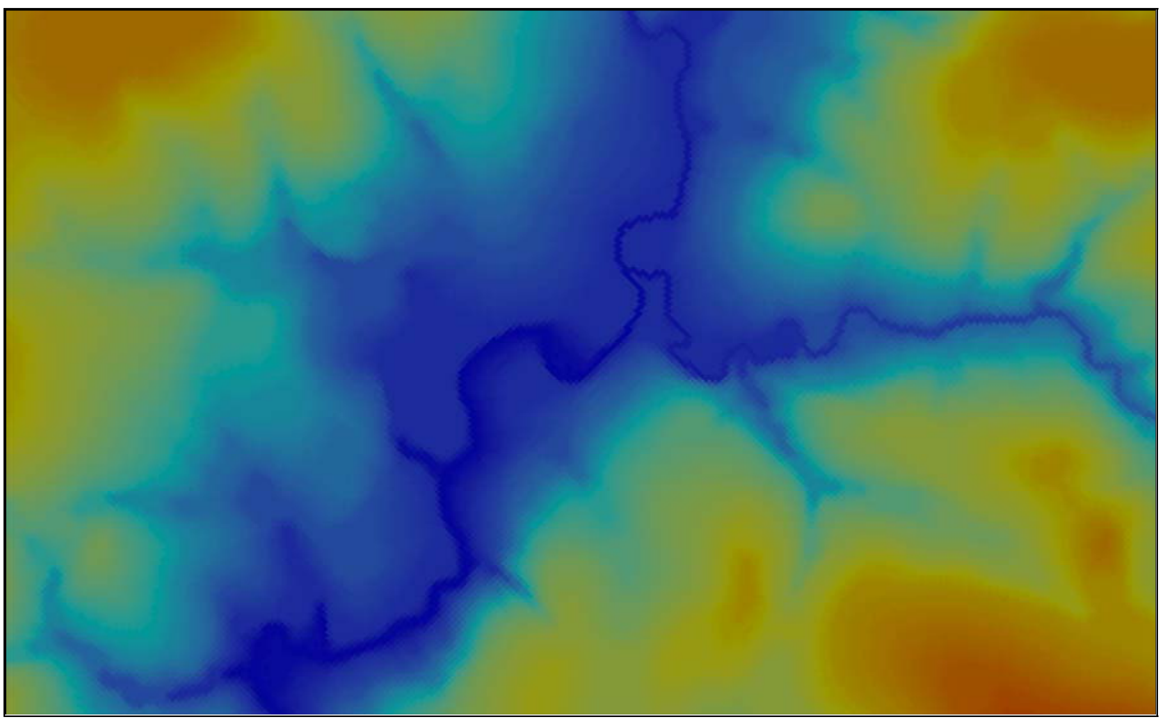

Figure 6.3 Fayette County Sample Terrain DEM Raster (50-feet cells)

6.2 HYDROLOGY

Basin drainage points (S_HydroNode) are defined at particular locations, and a basin (S_HydroBasin) is created for each drainage point. The WISE® Hydrology Module was used to automatically create basin drainage points at specified drainage area increments (calculated from the terrain model) and delineate a basin for each drainage point. An example of DEM streams, drainage points, and basins is presented in Figure 6.4. Parameters such as drainage area and main channel slope are computed at each drainage point for the precipitation regression *equation* (L_HydroEquation) used in approximate studies, and those *parameters* are recorded in the L_HydroParam table. The *value* of each regression parameter at each node is recorded in the L_HydroNodeParam table. Also, HEC-HMS rainfall-runoff models were used for the detailed studies in Fayette County.

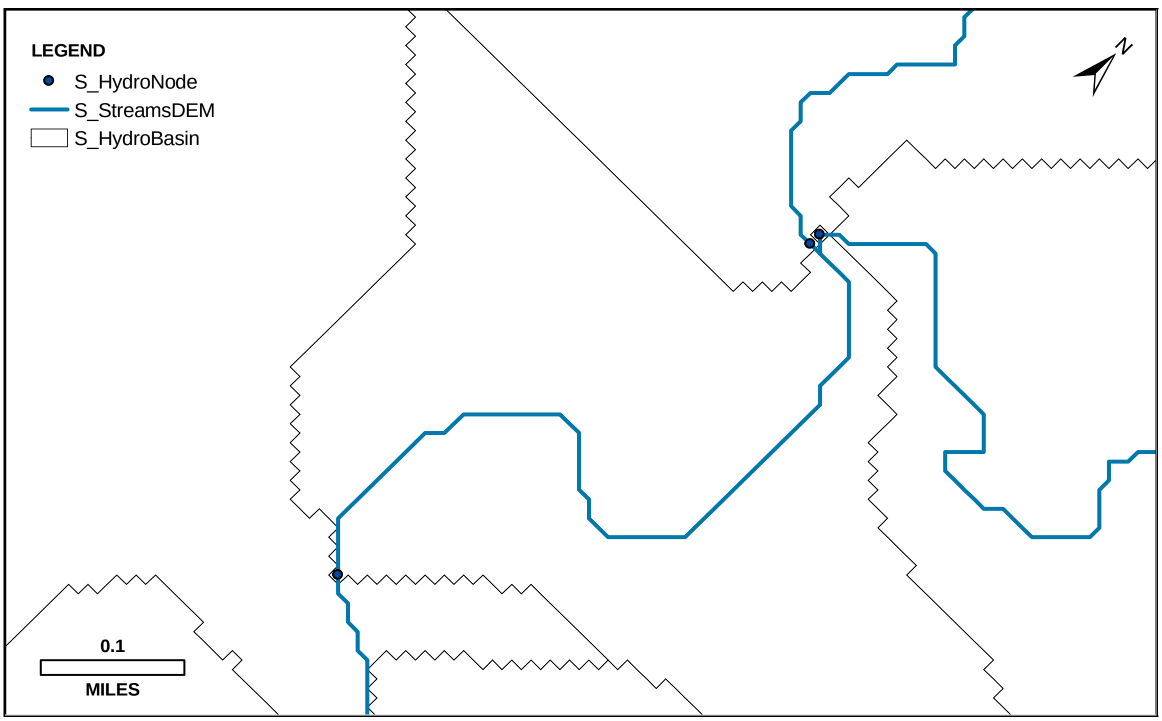

Figure 6.4 Fayette County Sample Hydrologic Features

6.3 Hydraulics

Stream centerline features for Fayette County are based on the medium-resolution National Hydrography Dataset (100K NHDFlowline) and rectified to high-resolution aerial photography. (The 24K NHD was not used because it was not yet available at the beginning of the Fayette project.) Stream centerlines are stationed by assigning the downstream end a value of zero and measuring the length in feet along the stream centerline towards the upstream end. Hydraulic cross-sections (S_HydraCrossSection) are drawn transverse to the direction of flow and are used in one-dimensional hydraulic models (HEC-RAS). The WISE® Hydraulics Module was used to automatically draw a hydraulic cross-section at specified stationing intervals along a stream centerline, and nearly 4900 hydraulic cross-sections were created for Fayette County.

Take-offs were performed automatically with the WISE® Hydraulics Module to collect elevation data from the terrain model to add “z” values along the planimetric streamlines and cross-sections. These three-dimensional features are the basis of hydraulic models and provide the link between the GIS framework of physical dimensions and the hydraulic model framework. The stream centerline features (S_StreamCntrLine) are the “backbone” of the Flood Study Geodatabase as it provides the basis for stream stationing (length in feet of measurement along the reach), and the hydraulic cross-section features (S_HydraCrossSection) are the “ribs” that form bathymetry.

The WISE® HydraMAX tool was used to create a HEC-RAS hydraulic model for each reach. Each HEC-RAS model was inspected, executed, and reviewed by a second engineer. Water surface elevation values from the hydraulic models are intersected with the terrain model to define flood boundaries, which are stored in the S_HydraMapping feature class. An example of the stream centerline, cross-sections, and flood boundaries is shown in Figure 6.5.

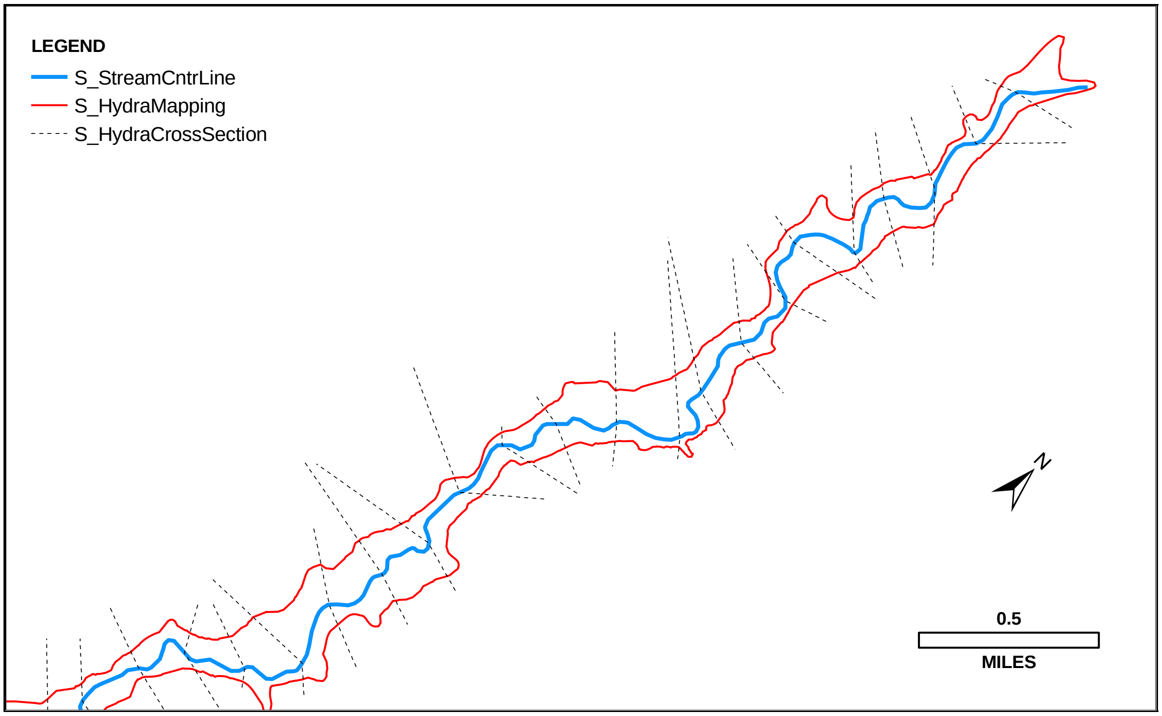

Figure 6.5 Fayette County Sample Hydraulic Features

The review of the flood hazard study process and Flood Study Geodatabase reveals that the fundamental elements of the hydrologic and hydraulic modeling are the basins, drainage points, stream centerlines, and hydraulic cross-sections. These features and their attributes are the connection between geographic and modeling coordinate systems. An example of these core data and their respective Flood Study Geodatabase (FSG) feature classes is presented in Figure 6.6

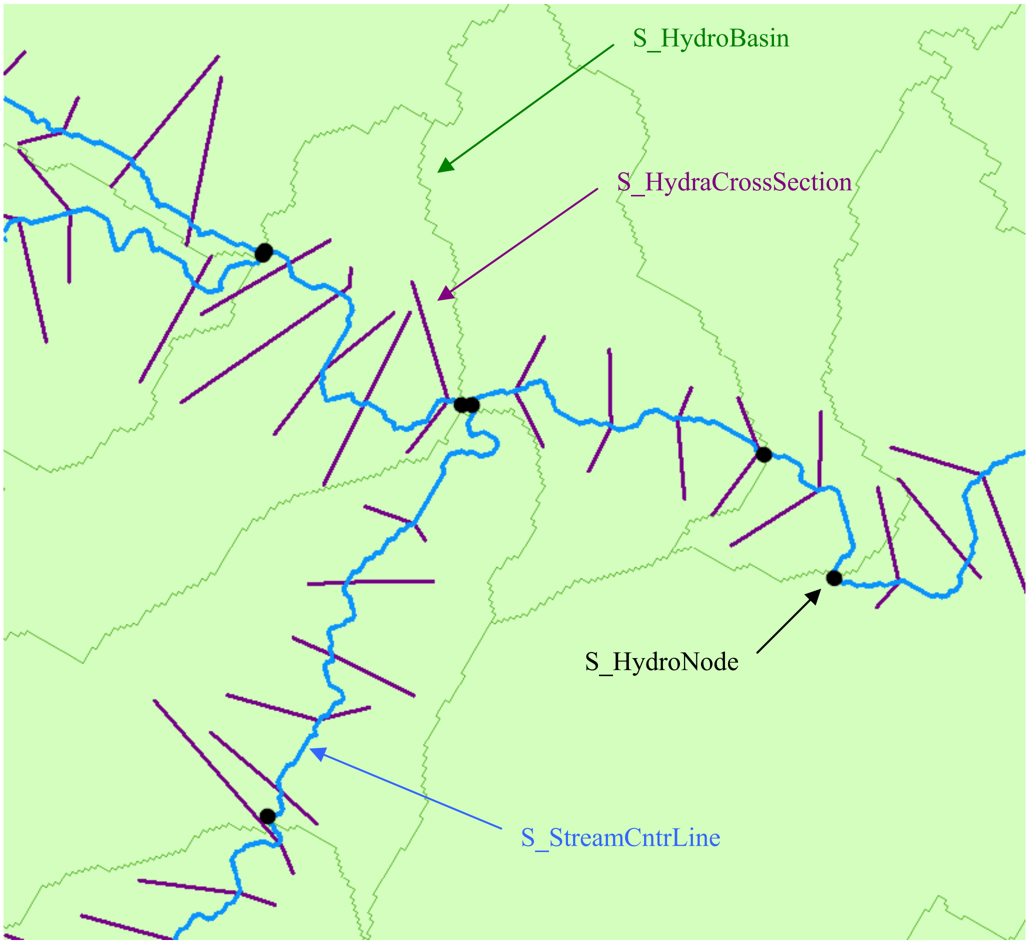

Figure 6.6 Core FSG Hydrologic and Hydraulic Features

6.4 DFIRM

Basemap features such as political boundaries (S_Pol_Ar and S_Pol_Ln), transportation lines (S_Trnsport_Ln), and permanent benchmarks (S_Perm_Bmk) are shown on Flood Insurance Rate Maps for jurisdiction and physical reference. Political boundaries and transportation lines for Fayette County were acquired from the Texas Capital Area Council of Governments (CAPCO) website at http://www.capco.state.tx.us. The permanent benchmarks were obtained from the National Geodetic Survey (NGS) website at http://www.ngs.noaa.gov/cgi-bin/ds_county_sf.prl. The S_FIRM_Pan feature class records the spatial extent of each FIRM panel. An example of these basemap features for Fayette County is presented in Figure 6.7.

Hydrographic water features such as streams and rivers appearing on the FIRMs are stored in the S_Wtr_Ln, and water features such as lakes and ponds are stored in the S_Wtr_Ar feature classes. Most of these features are acquired from the NHD or a local GIS data provider, but some of the features are digitized from aerial photography or effective FIRMs. After erroneous island and pond features have been removed from the S_HydraMapping feature class, the processed flood hazard boundaries are stored in the S_Fld_Haz_Ln and S_Fld_Haz_Ar feature classes. An example of the extensive spatial coverage of these hydrographic feature classes is shown in Figure 6.8.

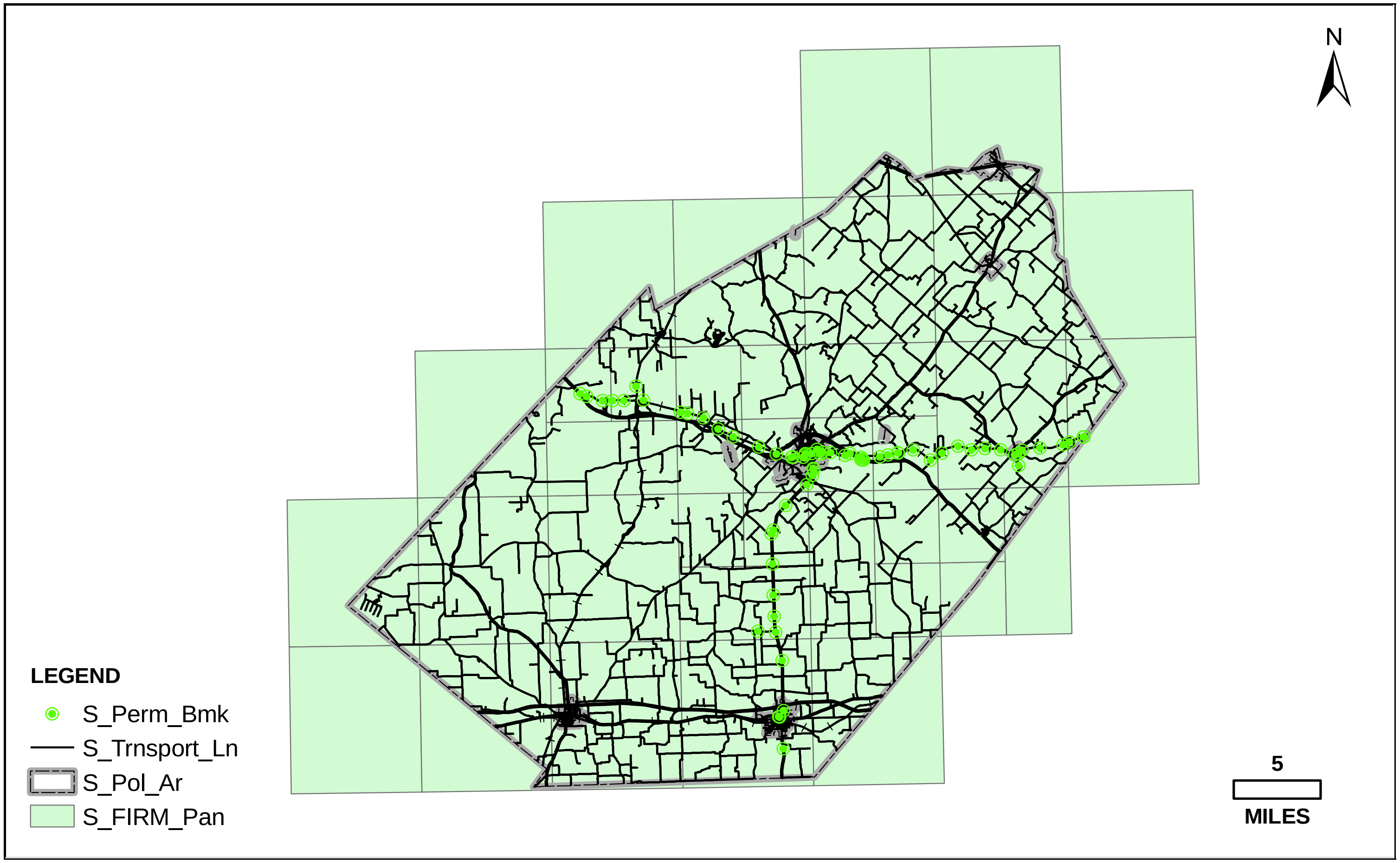

Figure 6.7 Fayette County FIRM Features - Basemap

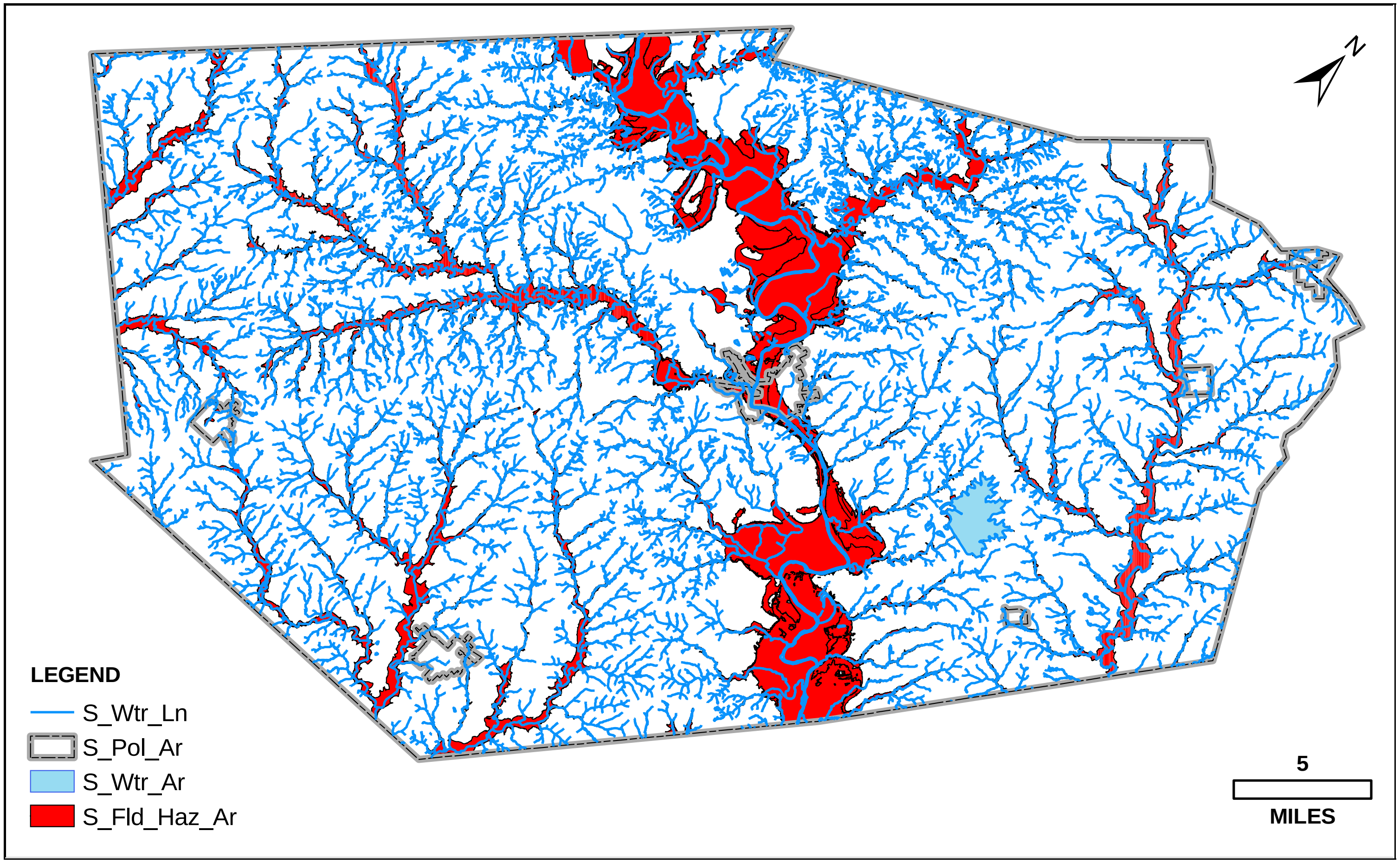

Figure 6.8 Fayette County FIRM Features - Hydrography

6.5 Relation to the National Hydrography Dataset (NHD)

After the Fayette County Flood Hazard Mapping Project was completed, a comparison was made among the high-resolution (24K) NHDFlowline, medium-resolution (100K) NHDFlowline, and S_StreamCntrLine features in Fayette County. It was discovered that the spatial extent of the dataset increased in the order of 100K NHDFlowline, S_StreamCntrLine, and 24K NHDFlowline, as illustrated in Figure 6.9. Moreover, there are a few S_StreamCntrLine features that are not covered by the spatial extent of the 100K NHDFlowline, but *every* feature in the S_StreamCntrLine feature class can be represented by a feature in the 24K NHDFlowline feature class.

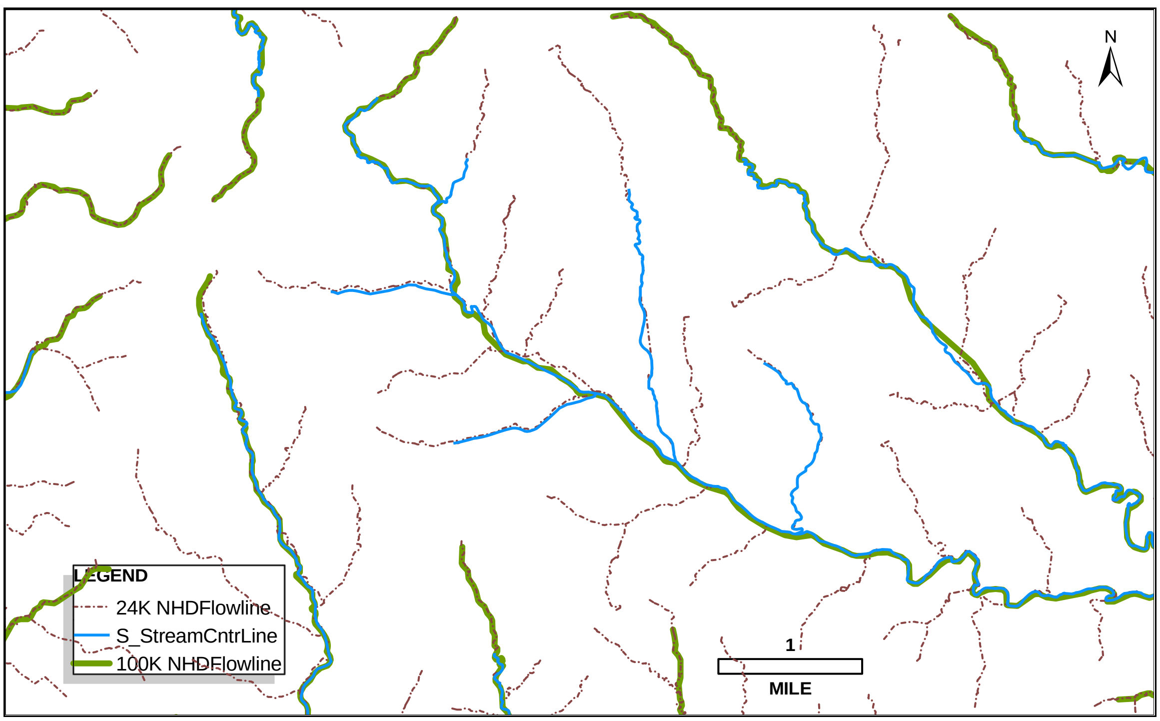

Figure 6.9 Comparison of 100K NHD, S_StreamCntrLine, and 24K NHD

Digital Enhancement Services, a GIS consulting firm specializing in conflation, performed a pilot-study conflation of the stream centerlines (S_StreamCntrLine) and the high-resolution National Hydrography Dataset (24K NHDFlowline) in the Cummins Creek watershed in eastern Fayette County (shown in Figure 6.10). *Conflation* is the process of transferring attributes from one geographic dataset to another similar, but slightly different geographic dataset. In this case, the unique identification (StrmLineID) of each S_StreamCntrLine feature in the pilot-study was "mapped" to the corresponding 24K NHDFlowline ReachCode. Furthermore, the position of each S_StreamCntrLine feature along the corresponding NHD reach was determined by recording the NHDFlowline reach "measure" values at the ends of each stream centerline by interactively using the "Identify Route Locations" tool in ArcMap. In the NHD network, "From-Measure" is the upstream end (greater value), and the "To-Measure" is the downstream end (lesser value). An illustration of the native data used in the conflation process is presented in Figure 6.11 where the blue lines represent S_StreamCntrLine features, the blue labels are the StrmLineID values, the brown lines represent 24K NHDFlowlines, and the brown labels are the ReachCode values. An example of how this data is entered in the L_NHD_LinearEvent table is also presented in Figure 6.11. An example of data entry for a single S_StreamCntrLine feature overlapping multiple NHD reaches is shown in Figure 6.12.

The conflation pilot-study successfully demonstrated that each Fayette S_StreamCntrLine feature could be correlated with a reach on the 24K NHDFlowline (although there may be locations in the United States where this is not true.) This correlation between the S_StreamCntrLine feature class and the 24K NHDFlowline is the inspiration for the Flood Study Geodatabase L_NHD_LinearEvent table.

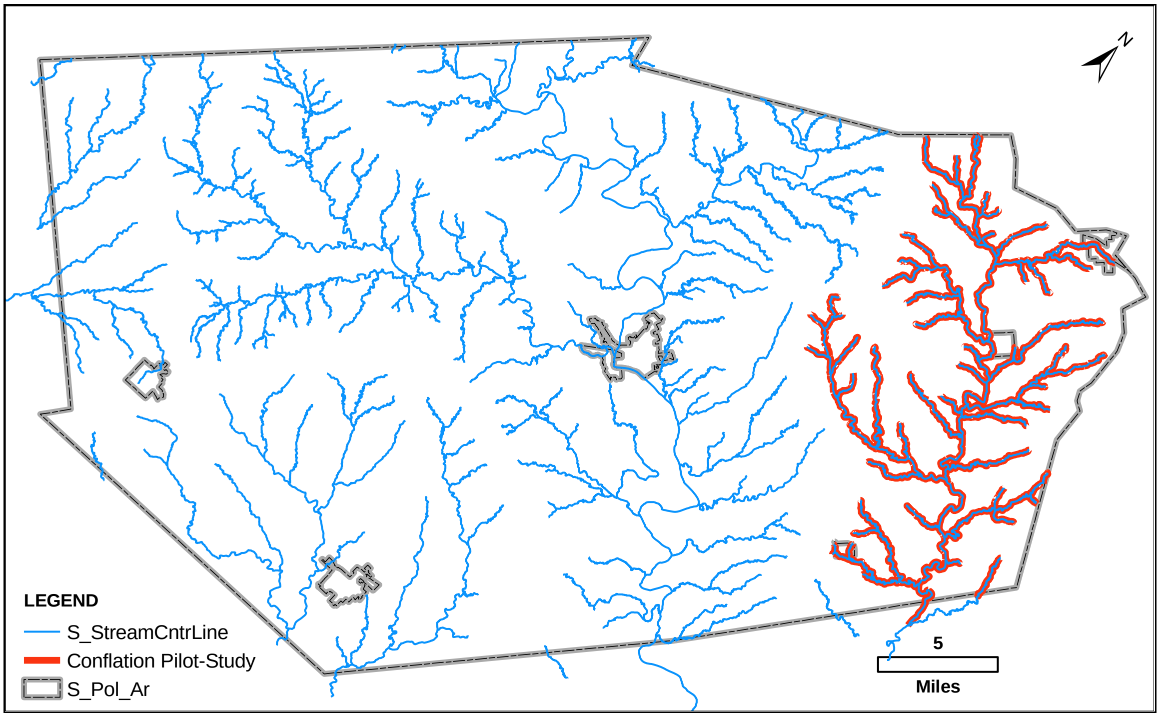

Figure 6.10 Fayette County Stream-Conflation Pilot-Study Region

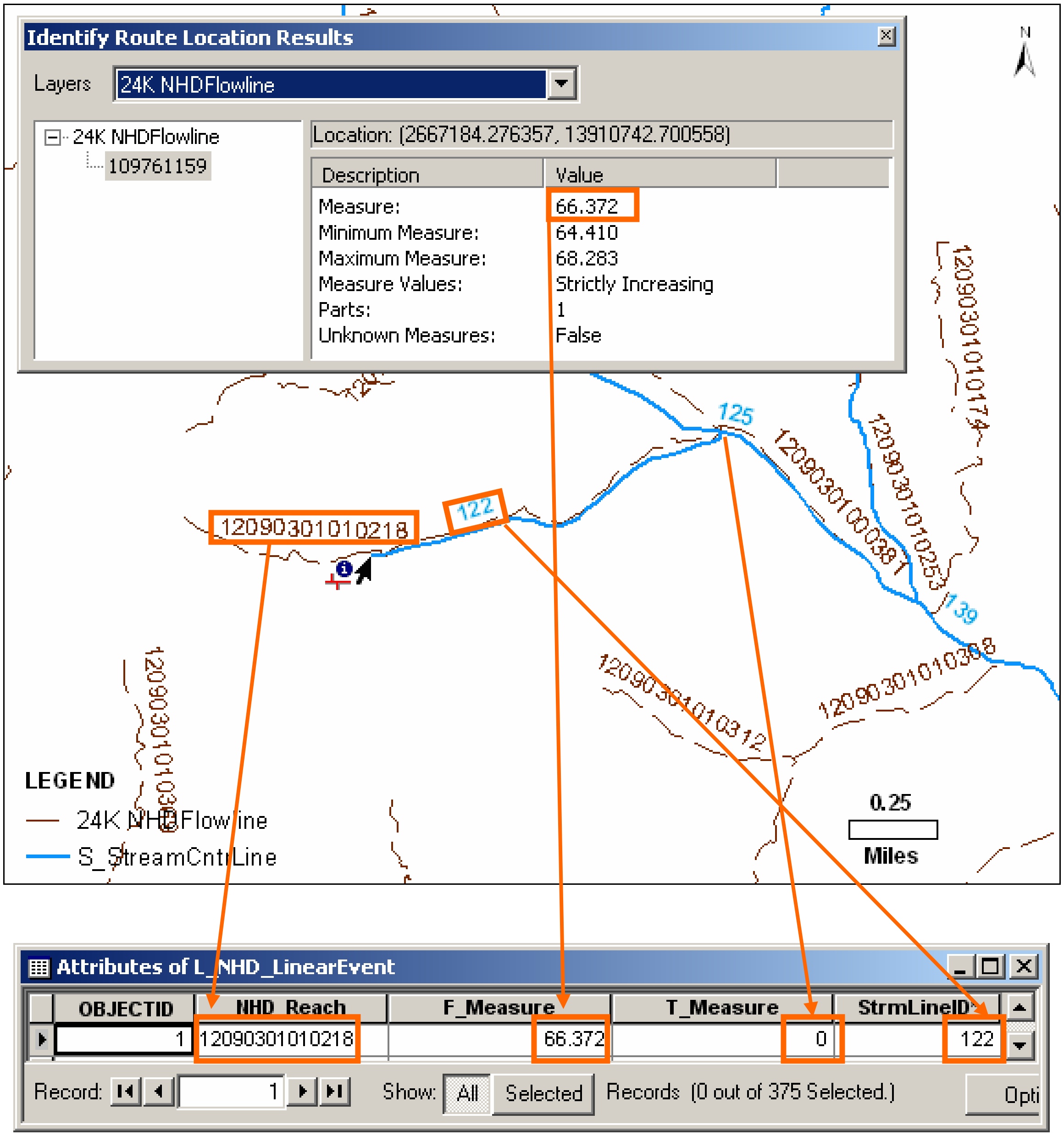

Figure 6.11 L_NHD_LinearEvent Table - Single Reach Example

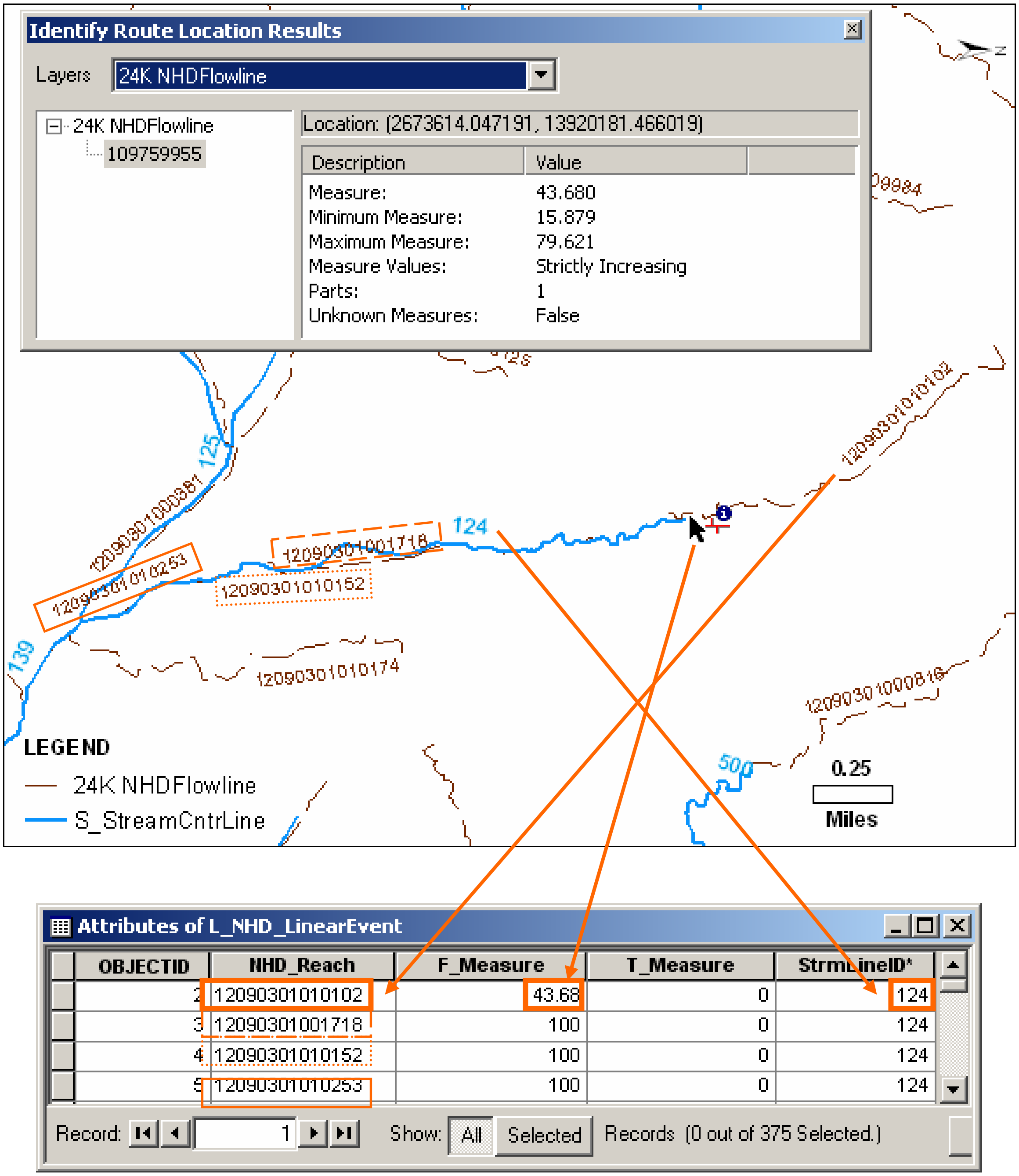

Figure 6.12 L_NHD_LinearEvent Table - Multiple Reach Example

Within an ESRI ArcMap session, an FSG user can create line events with the L_NHD_LinearEvent table by using the "Add Route Events…" option in the "Tools" menu. The L_NHD_LinearEvent table and the 24K NHDFlowline feature class are entered in the "Add Route Events" dialogue box illustrated in Figure 6.13, and the user must specify the "From" and "To" measure fields.

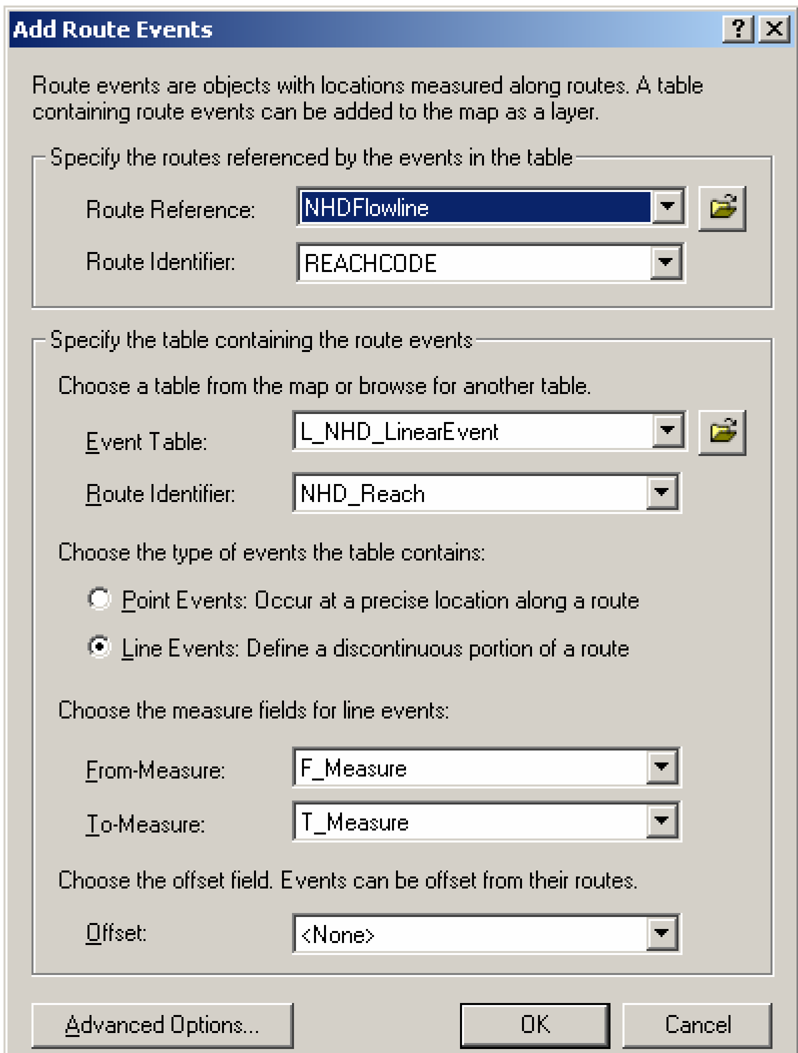

Figure 6.13 ESRI ArcMap Add Route Events Dialogue Box

The resulting line events (thick, solid, red lines) have the same geometry as the 24K NHDFlowline features (dashed lines) but have the extent of the S_StreamCntrLine features (thin, solid, blue lines). This route event option allows a user to display the FEMA stream model extent on the NHD network and utilize the advantages of the NHD network (trace upstream, distance to downstream location, *etc.*)

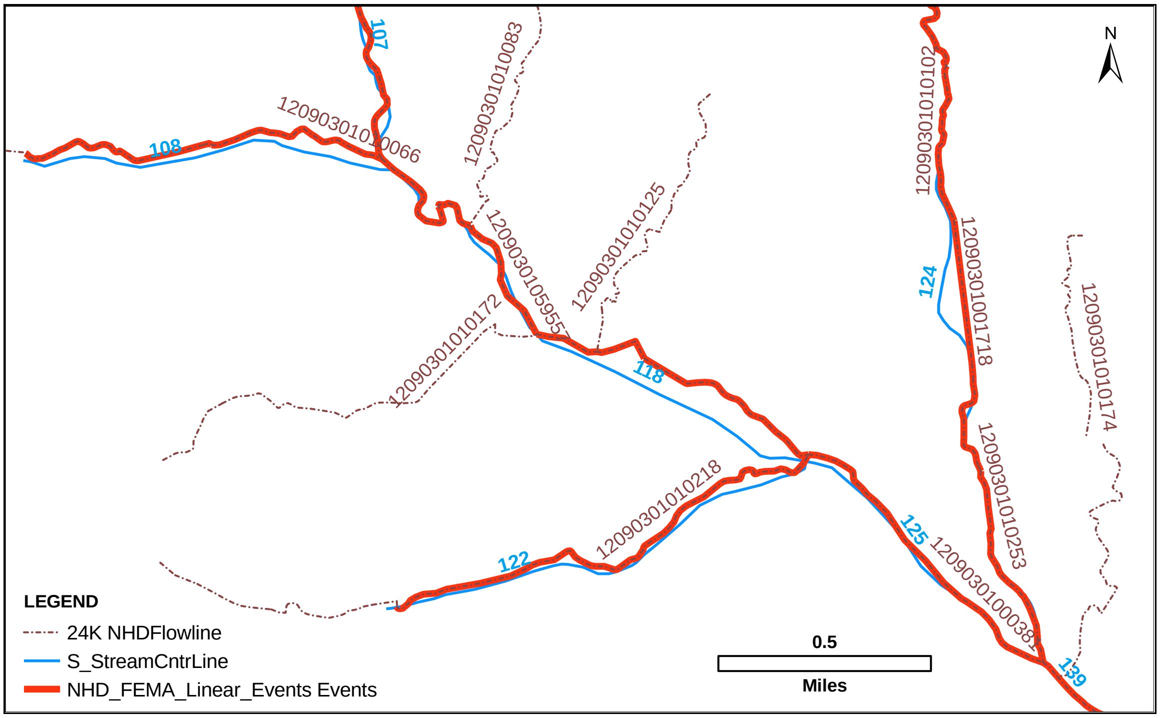

Figure 6.14 Fayette County Sample FEMA-NHD Linear Events

Chapter 7 Conclusions

7.1 FLOOD STUDY GEODATABASE (FSG) DESIGN SUMMARY

7.1.1 Merge DFIRM and DCS Databases

The review of DFIRM and DCS database tables revealed that the DFIRM and DCS databases could be merged and that several tables could be consolidated. There are two conflict-resolution situations in merging the DFIRM and DCS databases. First, if a DFIRM table and DCS table have the same name and fields, then the DCS table is retained and the DFIRM table is discarded. The second situation occurs when a DFIRM table and a DCS table are identified as containing similar information, in which case the tables are consolidated into the DCS table if determined to represent duplicate information. This preferential selection of DCS tables in conflict resolution occurs because the DCS designers followed the DFIRM database precedence in many ways, but took the opportunity to improve similar tables through field type modifications, eliminating unnecessary fields, and adding useful fields.

7.1.2 Upgrade the Relational Database System to a Geodatabase

The DFIRM and DCS databases were originally designed as relational databases with geographic information. In addition to merging the DFIRM and DCS databases, the Flood Study Geodatabase (FSG) is the result of converting the relational database system to an ESRI® geodatabase in three ways. First, the spatial "S_" tables in the DFIRM and DCS are stored as feature classes in the FSG and united in a single feature dataset. Second, the DFIRM and DCS lookup "L_" tables are represented in the FSG as geodatabase tables (object classes). Third, domain "D_" tables in the DFIRM and DCS are implemented as coded value domains in the FSG.

7.1.3 Relate the FSG to Arc Hydro

Many people in the water resources community are familiar with the Arc Hydro data model, so the description of similarities between the Flood Study Geodatabase and the Arc Hydro data model in Chapter 4 provides the necessary information for Arc Hydro users to migrate useful data from the FSG to their Arc Hydro geodatabase. The FSG contains feature classes that are directly analogous to feature classes in each of the four Arc Hydro feature datasets, as summarized in Figure 4.6.

The FSG S_StreamCntrLine and S_HydraCrossSection feature classes match the ProfileLine and CrossSection feature classes in the Arc Hydro Channel feature dataset. Also, the S_StreamsDEM, S_HydroNode, and S_HydroBasin feature classes in the FSG correlate with the DrainageLine, DrainagePoint, and Watershed feature classes in the Arc Hydro Drainage feature dataset. Furthermore, the S_Fld_Haz_Ar, S_Wtr_Ln, S_HydroGage, and S_Wtr_Ar feature classes in the FSG correspond to the HydroArea, HydroLine, MonitoringPoint, and Waterbody feature classes in the Arc Hydro Hydrography dataset.

7.1.4 Relate the FSG to the National Hydrography Dataset (NHD)

Another dataset that is used by a large proportion of the water resources community is the National Hydrography Dataset (NHD), which includes GIS data of streamlines, water bodies, watersheds, and other hydrographic data. Through the use of a linear event table (L_NHD_LinearEvent), the stream centerline (S_StreamCntrLine) features are related to the high-resolution NHDFlowline. This NHD relationship adds a valuable macroscopic networking functionality to the FEMA Flood Study Geodatabase that is analogous to the Network feature dataset in the Arc Hydro data model. Moreover, this NHD relationship allows the FEMA GIS data to be referenced to the official U.S. stream network.

7.1.5 FEMA GIS Design Considerations

Over the course of this project, several design considerations have emerged that should be carefully discussed by FEMA administrative personnel as they design the next generation of FEMA GIS archival. The following is a list of comments and questions that must be definitively verified or answered in order to produce a utilitarian FEMA GIS.

The appendix that supersedes DFIRM and DCS should clearly contrast the fundamental differences between "engineering" datasets and "cartographic" datasets with specific feature class examples. For example, the S_StreamCntrLine feature class is an engineering dataset because it is a network of logically connected features that are related to engineering models, whereas the S_Wtr_Ln feature class may contain additional stream features that were not modeled and are used for cartographic purposes. Again, the S_HydraBFE feature class records geometric features that are direct results from engineering models, whereas the S_BFE feature class records features that have been modified to satisfy aesthetic or cartographic requests and may or may not represent precise engineering results.

As FEMA is revisiting the design of this flood hazard GIS, there exists an opportunity to dispose of a deceptive term that has perhaps misguided the public, that is, the “return period.” As most engineers familiar with hydrologic modeling are aware, the “return period” is simply the reciprocal of the probability that a given event will be equaled or exceeded. However, this term (as it has been applied to the 100-year and 500-year floods) has perhaps created a deception of the public that a given event will occur on a predetermined schedule, as opposed to the random occurrences of reality. Thus, in the new appendix, all references to “return period” should be replaced with “exceedance probability,” (or something to that effect) which is a much more precise nomenclature.

Another decision facing FEMA administration is the question, "Who is the end-user of this database/dataset?" Is this FEMA flood hazard GIS being developed for internal/governmental use only, or will the data be considered "public" and made available to the any web users through online portals? It is imperative that the administrators realize that the flood hazard GIS data is *invaluable* to many scientific and engineering disciplines because of the integral role that surface water resources play in our society and environment. To that regard, the following is a list of several questions that should be addressed by FEMA administrators in the creation of the next-generation, flood hazard GIS:

- Who is the "end-user" of this data, and what types of data queries should the FSG support?
- Should the Geodatabase have "versions" or "editions" of data, or should it be continuously updated?
- How much relationship redundancy is required or optimal in the FSG fields? (e.g., stream line ID, vertical datum, horizontal datum, etc.)
- Should the feature class and table names retain the prefix descriptors (S_, L_, and D_), or are they overly redundant in the Geodatabase environment?
- Should the feature class and table names be modified to be more descriptive and less cryptic?
- Should each feature of every feature class have a "SourceCit" field entry to reference metadata, or should metadata be stored in the ESRI metadata system by feature class?

7.2 Alternative Database Design Methods

Instead of the using the standard ESRI user interfaces, custom database creation tools were developed and used in this project to create an ESRI geodatabase schema. An

Excel spreadsheet is used to store the schema details, and a Visual Basic for Applications (VBA) script is used to create an extensible markup language (XML) file of the FSG schema that is compatible with the public Geodatabase Designer 2 toolbar.

This system proves to be much more user-friendly than the standard ESRI user interfaces because it allows a geodatabase designer to make schema edits in the spreadsheet environment and produce a geodatabase at the completion of the design process, as opposed to struggling through tedious manual data entry.

Though the XML version implemented in this research does not accommodate data transfer (*i.e.*, the XML file implemented in this project only supports an empty geodatabase *schema*), the Geodatabase Designer 2 XML is valuable as a well-documented open-source representation of an ESRI Geodatabase with tools to expediently manufacture geodatabases. An alternative that does support GIS data transfer is the XML Workspace document that can be created from ESRI's ArcCatalog, which should be considered for a potential FEMA submittal data type because it is simply a text file.

7.3 RECOMMENDATIONS

The Flood Study Geodatabase (FSG) rectifies the conflict between the DFIRM and DCS databases and employs several technological improvements with minimal disturbance to the current Map Modernization program. Therefore, it is recommended that FEMA use the Flood Study Geodatabase as a prototype in the review process to develop a geodatabase that will merge and supersede the DFIRM and DCS databases. In such case, FEMA will save an enormous amount of time and financial expenditures that would have been necessary in the standard bureaucratic process to develop the FSG. Also, the benefits of the consolidation of the DFIRM and DCS databases will immediately extend to the Mapping Partners, allowing them to "streamline" their mapping production process.

In addition to submitting DFIRM and DCS data, Flood Hazard Mapping Partners are required to submit a Technical Support Data Notebook (TSDN) according to Appendix M of the *Guidelines and Specifications for Flood Hazard Mapping Partners*, which contains a hard copy of information about the Mapping Project. In many cases this TSDN contains duplicated data from the Flood Study Geodatabase and the Flood Insurance Study (FIS) report. Thus, in order to improve the Map Modernization Program, it is necessary to remove this duplication of effort and integrate the information from the TSDN into the Flood Study Geodatabase or the FIS report.

There is currently a widespread development of cyberinfrastructure to create online data-sharing programs such as "WaterOneFlow" web services and the Hydrologic Data Access System (HDAS) hosted by the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI), the Arc Hydro Server, and others made public through ESRI® ArcExplorer and Google Earth®. The United States government is making a large financial investment in developing this valuable GIS data from FEMA flood studies, and it is imperative that these resources be efficiently managed and served to the public. As more hydrologic and hydraulic data becomes available, engineers and scientists of many disciplines are able to perform higher-level analyses that advance the understanding of natural and anthropological processes in their respective fields. Implementation of a Flood Study Geodatabase at the federal and state levels will improve the utility of FEMA's multi-billion dollar investment in flood hazard data.

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Appendix A: VBA Script (*Write XML)*

The following VBA script was written to transpose the geodatabase design contained in a Microsoft Excel© spreadsheet into an intermediate XML document that could then be imported into an ESRI® geodatabase using the *Geodatabase Designer 2* toolbar. This VBA script was created and used on a Windows XP Professional® operating system running Microsoft® Office Excel 2003.

```
Sub WriteXML()

    'Created:   2006 MAY
    'Creator:   Shane Walker, EIT
    '           Center for Research in Water Resources (CRWR)
    '           Environmental and Water Resources Engineering (EWRE)
    '           The University of Texas at Austin

    'This application creates an XML geodatabase schema to be imported into an ESRI® geodatabase using
     the Geodatabase Designer 2 toolbar.


    Dim fso As New FileSystemObject
    Dim ts As TextStream
    Dim filename As String
    Dim message As String
    Dim c_month, c_day, c_hour, c_second As String  'metadata: creation date components
    Dim n As Integer            'counter
    Dim stfield As String       'subtype field
    Dim stcode As String        'default subtype code


    'XML file location and name
    filename = InputBox("Please input the XML path and filename.", "XML Filename", "C:\_FSG.xml")
    If filename = "" Then GoTo 9999
    Set ts = fso.CreateTextFile(filename, True, True)


    'Header
    ts.WriteLine "<?xml version=""1.0"" encoding=""UTF-16"" standalone=""no""?>"
    ts.WriteLine "<?xml-stylesheet type=""text/xsl"" href=""C:\Program Files\ArcGIS\Geodatabase
     Designer 2\XSL\Geodatabase Designer.xsl""?>"
    ts.WriteLine "<geodatabaseDesigner version=""2.0.345"">"


    'Metadata
    ts.WriteLine "      <metadata>"
```

```
If Len(month(Now)) = 1 Then
    c_month = "0" & month(Now)
Else: c_month = month(Now)
End If
If Len(day(Now)) = 1 Then
    c_day = "0" & day(Now)
Else: c_day = day(Now)
End If
If Len(hour(Now)) = 1 Then
    c_hour = "0" & hour(Now)
Else: c_hour = hour(Now)
End If
If Len(Minute(Now)) = 1 Then
    c_minute = "0" & Minute(Now)
Else: c_minute = Minute(Now)
End If
If Len(second(Now)) = 1 Then
    c_second = "0" & second(Now)
Else: c_second = second(Now)
End If
ts.WriteLine "            <creationDate year=""" & year(Now) & """ month=""" & c_month & """
 day=""" & c_day & """ hour=""" & c_hour & """ minute=""" & c_minute & """ second=""" & c_second &
 """/>"
ts.WriteLine "            <creator user=""Shane Walker"" computer=""SIGMA5000""/>"
ts.WriteLine "            <geodatabase esriWorkspaceType=""1"" flavor=""Access""
 version=""2.0.1"">"
ts.WriteLine "                  <connectionProperty name=""DATABASE"" value=""""/>"
ts.WriteLine "            </geodatabase>"
ts.WriteLine "      </metadata>"


'Domains
Worksheets("Domains").Activate
Range("A4").Select
Do Until Selection = ""
    ts.WriteLine "  <domain name=""" & Selection & """ description=""" & ActiveCell.Offset(0, 2)
    & """ owner="""" esriDomainType=""2"" esriFieldType=""0"" esriMergePolicyType=""3""
    esriSplitPolicyType=""3"">"
```

```
    ActiveCell.Offset(1, 1).Select
    Do Until Selection = ""
        ts.WriteLine "          <member name=""" & ActiveCell.Offset(0, 1) & """ value=""" &
        Selection & """/>"
        ActiveCell.Offset(1, 0).Select
    Loop
    ts.WriteLine "  </domain>"
    ActiveCell.Offset(1, -1).Select
Loop


'Feature Datasets and Feature Classes
Worksheets("FeatureClasses").Activate
Range("A4").Select
Do Until Selection = ""    'Loop through all feature datasets
    ts.WriteLine "  <featureDataset database="""" owner="""" table=""" & Selection & """>"
    ts.WriteLine "      <spatialReference minX=""-10000"" minY=""-10000""
    precisionXY=""100000"" minM=""0"" precisionM=""100000"" minZ=""0"" precisionZ=""100000""
    coordinateSystemDescription=""GEOGCS[&quot;GCS_North_American_1983&quot;,DATUM[&quot;D_North_A
    merican_1983&quot;,SPHEROID[&quot;GRS_1980&quot;,6378137.0,298.257222101]],PRIMEM[&quot;Greenw
    ich&quot;,0.0],UNIT[&quot;Degree&quot;,0.0174532925199433]]""/>"
    ActiveCell.Offset(1, 1).Select
    Do Until Selection = ""    'Loop through all feature classes within a feature dataset
        stfield = ActiveCell.Offset(0, 6)
        stcode = ActiveCell.Offset(0, 7)
        ts.WriteLine "          <objectClass database="""" owner="""" table=""" & Selection & """
        aliasName=""" & Selection & """ oidField=""OBJECTID"" esriDatasetType=""5""
        esriFeatureType=""1"" shapeField=""SHAPE"" subtypeField=""" & stfield & """
        defaultSubtypeCode=""" & stcode & """ modelName=""" & Selection & """
        configKeyword="""">"
        ts.WriteLine "                <field name=""OBJECTID"" aliasName=""OBJECTID""
        esriFieldType=""6"" length=""4"" precision=""0"" required=""True"" scale=""0""
        domainFixed=""False"" editable=""False"" isNullable=""False"" modelName=""OBJECTID""/>"
        ts.WriteLine "                <field name=""Shape"" aliasName=""Shape""
        esriFieldType=""7"" length=""0"" precision=""0"" required=""True"" scale=""0""
        domainFixed=""False"" editable=""True"" isNullable=""True"" modelName=""Shape"">"
```

```
ts.WriteLine "                      <geometryDef esriGeometryType=""" &
ActiveCell.Offset(0, 2) & """ avgNumPoints=""0"" hasM=""" & ActiveCell.Offset(0, 4) & """
hasZ=""" & ActiveCell.Offset(0, 5) & """>"
ts.WriteLine "                            <grid size=""1000""/>"
ts.WriteLine "                      </geometryDef>"
ts.WriteLine "                </field>"
ActiveCell.Offset(3, 8).Select
n = 0                       'initialize counter
Do Until Selection = ""     'Loop through all fields within a feature class
    n = n + 1               'Count the number of fields
    ts.WriteLine "                  <field name=""" & Selection & """ aliasName=""" &
    Selection & """ esriFieldType=""" & ActiveCell.Offset(0, 1) & """ length=""" &
    ActiveCell.Offset(0, 3) & """ precision=""" & ActiveCell.Offset(0, 4) & """
    required=""" & ActiveCell.Offset(0, 6) & """ scale=""" & ActiveCell.Offset(0, 5) & """
    domainFixed=""False"" editable=""True"" isNullable=""False"" modelName=""" & Selection
    & """/>"
    ActiveCell.Offset(1, 0).Select
Loop    'Loop fields
ts.WriteLine "                <subtype name="""" code="""">"
ActiveCell.Offset(-n, 7).Select
For i = 1 To n  'Loop through base domains
    If Selection <> "" Then ts.WriteLine "                        <field name=""" &
    ActiveCell.Offset(0, -7) & """ defaultValue="""" domain=""" & Selection & """/>"
    ActiveCell.Offset(1, 0).Select
Next i  'Loop base domains
ts.WriteLine "                </subtype>"
ActiveCell.Offset(0, 1).Select
If stfield <> "" Then
    Do Until Selection = ""     'Loop through all subtype codes and names
        ts.WriteLine "              <subtype name=""" & ActiveCell.Offset(0, 1) & """
        code=""" & Selection & """>"
        ActiveCell.Offset(1, 2).Select
        Do Until Selection = ""     'Loop through all subtype-specific domains
            ts.WriteLine "                      <field name=""" & Selection & """
            defaultValue="""" domain=""" & ActiveCell.Offset(0, 1) & """/>"
            ActiveCell.Offset(1, 0).Select
        Loop    'Loop subtype-specific domains
        ts.WriteLine "              </subtype>"
```

```
                ActiveCell.Offset(0, -2).Select
            Loop    'Loop subtype codes and names
            ts.WriteLine "                  <index name=""subtype_INDEX"" isAscending=""True""
            isUnique=""False"">"
            ts.WriteLine "                        <field name=""" & stfield & """/>"
            ts.WriteLine "                  </index>"
        End If
        ts.WriteLine "                  <index name=""FDO_OBJECTID"" isAscending=""True""
        isUnique=""True"">"
        ts.WriteLine "                        <field name=""OBJECTID""/>"
        ts.WriteLine "                  </index>"
        ts.WriteLine "                  <index name=""Shape_INDEX"" isAscending=""True""
        isUnique=""False"">"
        ts.WriteLine "                        <field name=""Shape""/>"
        ts.WriteLine "                  </index>"
        ts.WriteLine "            </objectClass>"
        ActiveCell.Offset(1, -16).Select
    Loop    'Loop feature classes
ActiveCell.Offset(0, -1).Select
ts.WriteLine "      </featureDataset>"
Loop   'Loop feature datasets


'Object Classes
Worksheets("ObjectClasses").Activate
Range("A4").Select
Do Until Selection = ""     'Loop through all object classes
    stfield = ActiveCell.Offset(0, 2)
    stcode = ActiveCell.Offset(0, 3)
    ts.WriteLine "  <objectClass database="""" owner="""" table=""" & Selection & """
    aliasName=""" & Selection & """ oidField=""OBJECTID"" esriDatasetType=""10""
    esriFeatureType="""" shapeField="""" subtypeField=""" & stfield & """ defaultSubtypeCode=""" &
    stcode & """ modelName=""" & Selection & """ configKeyword="""">"
    ts.WriteLine "        <field name=""OBJECTID"" aliasName=""OBJECTID"" esriFieldType=""6""
    length=""4"" precision=""0"" required=""True"" scale=""0"" domainFixed=""False""
    editable=""False"" isNullable=""False"" modelName=""OBJECTID""/>"
    ActiveCell.Offset(2, 4).Select
    n = 0                       'initialize counter
```

```
Do Until Selection = ""     'Loop through all fields within a feature class
    n = n + 1               'Count the number of fields
    ts.WriteLine "          <field name=""" & Selection & """ aliasName=""" & Selection & """
    esriFieldType=""" & ActiveCell.Offset(0, 1) & """ length=""" & ActiveCell.Offset(0, 3) &
    """ precision=""" & ActiveCell.Offset(0, 4) & """ required=""" & ActiveCell.Offset(0, 6)
    & """ scale=""" & ActiveCell.Offset(0, 5) & """ domainFixed=""False"" editable=""True""
    isNullable=""False"" modelName=""" & Selection & """/>"
    ActiveCell.Offset(1, 0).Select
Loop    'Loop fields
ts.WriteLine "        <subtype name="""" code="""">"
ActiveCell.Offset(-n, 7).Select
For i = 1 To n  'Loop through base domains
    If Selection <> "" Then ts.WriteLine "                <field name=""" &
    ActiveCell.Offset(0, -7) & """ defaultValue="""" domain=""" & Selection & """/>"
    ActiveCell.Offset(1, 0).Select
Next i  'Loop base domains
ts.WriteLine "        </subtype>"
ActiveCell.Offset(0, 1).Select
If stfield <> "" Then
    Do Until Selection = ""     'Loop through all subtype codes and names
        ts.WriteLine "            <subtype name=""" & ActiveCell.Offset(0, 1) & """ code="""
        & Selection & """>"
        ActiveCell.Offset(1, 2).Select
        Do Until Selection = ""     'Loop through all subtype-specific domains
            ts.WriteLine "              <field name=""" & Selection & """ defaultValue=""""
            domain=""" & ActiveCell.Offset(0, 1) & """/>"
            ActiveCell.Offset(1, 0).Select
        Loop    'Loop subtype-specific domains
        ts.WriteLine "            </subtype>"
        ActiveCell.Offset(0, -2).Select
    Loop    'Loop subtype codes and names
    ts.WriteLine "          <index name=""subtype_INDEX"" isAscending=""True""
    isUnique=""False"">"
    ts.WriteLine "                <field name=""" & stfield & """/>"
    ts.WriteLine "          </index>"
End If
ts.WriteLine "        <index name=""FDO_OBJECTID"" isAscending=""True"" isUnique=""True"">"
ts.WriteLine "              <field name=""OBJECTID""/>"
```

```
        ts.WriteLine "        </index>"
        ts.WriteLine "        <index name=""Shape_INDEX"" isAscending=""True"" isUnique=""False"">"
        ts.WriteLine "              <field name=""Shape""/>"
        ts.WriteLine "        </index>"
        ts.WriteLine "  </objectClass>"
        ActiveCell.Offset(1, -12).Select
    Loop    'Loop object classes


    'Relationships
    Worksheets("Relationships").Activate
    Range("A4").Select
    Do Until Selection = ""     'Loop through all relationships
        ts.WriteLine "  <relationshipClass database="""" owner="""" table=""" & Selection & """
        esriRelCardinality=""" & ActiveCell.Offset(0, 5) & """ esriRelNotification=""1""
        isComposite=""False"" isAttributed=""False"" originPrimaryKey=""" & ActiveCell.Offset(0, 2) &
        """ originForeignKey=""" & ActiveCell.Offset(0, 4) & """ destinationPrimaryKey=""""
        destinationForeignKey="""">"
        ts.WriteLine "        <featureDataset database="""" owner="""" table=""""/>"
        ts.WriteLine "        <origin database="""" owner="""" table=""" & ActiveCell.Offset(0, 1) &
        """ label=""" & ActiveCell.Offset(0, 1) & """/>"
        ts.WriteLine "        <destination database="""" owner="""" table=""" & ActiveCell.Offset(0,
        3) & """ label=""" & ActiveCell.Offset(0, 3) & """/>"
        ts.WriteLine "  </relationshipClass>"
        ActiveCell.Offset(1, 0).Select
    Loop    'Loop relationships


    'Finish writing XML and close the XML file
    ts.Write "</geodatabaseDesigner>"
    ts.Close
    Set ts = Nothing
    Set fso = Nothing

9999    If filename = "" Then
            message = "USER CANCELLED"
        Else
            message = "XML Complete"
```

```
        End If
    MsgBox (message)
End Sub
```

Appendix B: Flood Study Geodatabase Diagram

This appendix includes a diagram that illustrates the relationship between feature classes and object classes of the Flood Study Geodatabase and lists the coded value domains.

FEMA Flood Study Geodatabase

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Appendix C: Flood Study Geodatabase Attribute Tables

This appendix includes tables that specify the attributes of feature classes, object classes, coded value domains, and relationship classes within the Flood Study Geodatabase.

<u>Feature Class - Attribute Table</u> **<u>Page</u>**

Geodatabase Table - Attribute Table **Page**

Coded Value Domain - Attribute Table **Page**

S_ApxStr - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
ApxStr_ID	Long	-	-	-	R	-	Primary Key
StrmLineID	Long	-	-	-	R	-	Foreign key to L_Wtr_Nm. Surface water feature name.
CBElv	Double	-	8	2	R	-	Average channel bank elevation.
ChnlBotWd	Double	-	8	2	R	-	Width at the bottom of channel.
ChnlTopWd	Double	-	8	2	R	-	Width at the top of channel.
Comments	Text	254	-	-	A	-	General comments or notes.
Len_LID	Short	-	-	-	R	D_Length_Units	Length Units
MinElv	Double	-	8	2	R	-	Minimum elevation at structure.
RoadNm	Text	100	-	-	R	-	Road name or location of structure
Source_Cit	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)
StreamStn	Double	-	12	2	R	-	Distance along stream where structure intersects stream.
Struct_LID	Short	-	-	-	R	D_Struct_Typ	Structure Type
Struct_Nm	Text	50	-	-	R	-	Field name of the structure.
SurveyDt	Date	-	-	-	R	-	Date of survey.
TORElv	Double	-	8	2	R	-	Maximum top of road elevation at structure.
Wdth	Double	-	8	2	R	-	Hydraulic length of the structure (parallel to stream).

S_Base_Index - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
BASE_ID	Long	-	-	-	R	-	Primary Key
FILENAME	Text	50	-	-	R	-	Base Filename and extension of raster basemap.
BASE_DATE	Date	-	-	-	R	-	Date raster base map was acquired
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_BFE - Polyline Z Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
BFE_LN_ID	Long	-	-	-	R	-	Primary Key
ELEV	Double	-	8	2	R	-	The rounded, whole foot Base Flood Elevation
LEN_LID	Short	-	-	-	R	D_Length_Units	Length Unit
V_DATM_LID	Short	-	-	-	R	D_V_Datum	Vertical Datum
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_CBRS - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
CBRS_ID	Long	-	-	-	R	-	Primary Key
CBRS_LID	Short	-	-	-	A	D_CBRS_Typ	CBRS type
CBRS_DATE	Date	-	-	-	A	-	CBRS Date. (Legislative or administrative date)
CBRS_TF	Short	-	-	-	R	D_Boolean_TF	This field is True if the area is a CBRS or an OPA.
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Contour - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
ContourID	Long	-	-	-	R	-	Primary Key
Elev	Double	-	10	3	R	-	Elevation in feet
LEN_LID	Short	-	-	-	R	D_Length_Units	Length Units
V_DATM_LID	Short	-	-	-	R	D_V_Datum	Vertical Datum
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Cst_Gage - Point Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
GAGE_ID	Long	-	-	-	R	-	Primary Key
CST_MDL_ID	Long	-	-	-	A	-	Foreign Key to Coastal Model Identification.
GAGE_NM	Text	150	-	-	R	-	Gage name assigned by agency maintaining gage.
AGENCY	Text	150	-	-	R	-	Name of agency maintaining gage.
REC_INTVL	Text	11	-	-	A	-	Recording Interval (only if coastal gage is a fixed-interval gage.)
TIME_LID	Short	-	-	-	A	D_Time_Units	Recording Interval Time Unit
START_PD	Date	-	-	-	R	-	Gage Record Starting Date. (used in gage analysis)
END_PD	Date	-	-	-	R	-	Gage Record Ending Date. (used in gage analysis)
GAGE_LID	Short	-	-	-	R	D_Gage	Gage Type
WVDIR_TF	Short	-	-	-	R	D_Boolean_TF	Does the gage record wave direction?
WDSPD_TF	Short	-	-	-	R	D_Boolean_TF	Does the gage record wind speed?
WDDIR_TF	Short	-	-	-	R	D_Boolean_TF	Does the gage record wind direction?
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Cst_Tsct_Ln - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
TRAN_LN_ID	Long	-	-	-	R	-	Primary Key
TRAN_NO	Text	4	-	-	R	-	Transect Number (as shown on FIRM or in FIS)
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)
CST_MDL_ID	Long	-	-	-	A	-	Foreign Key to Coastal Model Identification.
SETUP_DPTH	Double	-	8	2	A	-	Wave Set-up Depth added to the 1% chance stillwater elevation.
SIG_HT	Double	-	8	2	A	-	1% chance Significant Wave Height
SIG_PD	Double	-	8	2	A	-	1% chance Significant Wave Period.
CON_HT	Double	-	8	2	A	-	Controlling Wave Height. (1.6 X significant wave height)
CON_PD	Double	-	8	2	A	-	Controlling Wave Period.
MEAN_HT	Double	-	8	2	A	-	Mean Wave Height.
MEAN_PD	Double	-	8	2	R	-	Mean Wave Period.
EROS_LID	Short	-	-	-	A	D_Eros_Meth	Erosion Methodology
TIME_LID	Short	-	-	-	R	D_Time_Units	Time Units
V_DATM_LID	Short	-	-	-	R	D_V_Datum	Vertical Datum
LEN_LID	Short	-	-	-	R	D_Length_Units	Length Unit
VZONE_LID	Short	-	-	-	R	D_VZone	V Zone Extent
METH_LID	Short	-	-	-	R	D_Method	Source Method
EFF_TF	Short	-	-	-	R	D_Boolean_TF	Is the coastal transect part of the effective study?
SHOWN_FIRM	Short	-	-	-	R	D_Boolean_TF	Is the transect shown on the FIRM?
SHR_LID	Short	-	-	-	R	D_Shr_Rough	Shoreline Roughness
L_RANGE	Double	-	8	2	R	-	Left Range of Coastal Transect.
L_DIRECT	Double	-	8	2	R	-	Direction of Left Range.
R_RANGE	Double	-	8	2	R	-	Right Range of Coastal Transect.
R_DIRECT	Double	-	8	2	R	-	Direction of Right Range.
LOC_DESC	Text	254	-	-	R	-	Coastal Transect Location Description.
XCOORD	Double	-	8	2	R	-	X-Coordinate of the 0.0-foot elevation point along the transect.
YCOORD	Double	-	8	2	R	-	Y-Coordinate of the 0.0-foot elevation point along the transect.

S_ExternalBoundary - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
BoundaryID	Long	-	-	-	R	-	Primary Key
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_FIRM_Pan - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
FIRM_ID	Long	-	-	-	R	-	Primary Key
ST_FIPS	Text	2	-	-	R	-	State FIPS. (two-digit code defined in FIPS Pub 6-4)
PCOMM	Text	4	-	-	R	-	Community or County Identification Number.
PANEL	Text	4	-	-	R	-	Panel Number.
SUFFIX	Text	1	-	-	R	-	Map Suffix.
FIRM_PAN	Text	11	-	-	R	-	FIRM Panel Number.
PANEL_LID	Short	-	-	-	R	D_Panel_Typ	Panel Type
EFF_DATE	Date	-	-	-	A	-	Effective Date.
SCALE_LID	Short	-	-	-	R	D_Scale	Map Scale
PNP_REASON	Text	50	-	-	A	-	Panel Not Printed Reason.
NW_LAT	Text	15	-	-	R	-	Northwest Latitude.
NW_LONG	Text	15	-	-	R	-	Northwest Longitude.
SE_LAT	Text	15	-	-	R	-	Southeast Latitude.
SE_LONG	Text	15	-	-	R	-	Southeast Longitude.
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Fld_Haz_Ar - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
FLD_AR_ID	Long	-	-	-	R	-	Primary Key
ZONE_LID	Short	-	-	-	R	D_Zone	Flood Hazard Zone Type
FLDWAY_LID	Short	-	-	-	A	D_Floodway	Floodway Type
SFHA_TF	Short	-	-	-	R	D_Boolean_TF	Special Flood Hazard Area?
STATIC_BFE	Double	-	8	2	A	-	Static Base Flood Elevation.
V_DATM_LID	Short	-	-	-	A	D_V_Datum	Vertical Datum
DEPTH	Double	-	8	2	A	-	Depth Value for Zone AO Areas.
LEN_LID	Short	-	-	-	A	D_Length_Units	Length Unit
VELOCITY	Double	-	8	2	A	-	Velocity Measurement.
VEL_LID	Short	-	-	-	A	D_Velocity_Unit	Velocity Unit
AR_REVERT	Short	-	-	-	A	D_Zone	If the area is AR, the revert zone if the AR zone were removed.
BFE_REVERT	Double	-	8	2	A	-	If Zone is AR,the static BFE for the reverted zone.
DEP_REVERT	Double	-	8	2	A	-	If Zone is AR, the flood depth for the reverted zone.
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Fld_Haz_Ln - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
FLD_LN_ID	Long	-	-	-	R	-	Primary Key
LN_LID	Short	-	-	-	R	D_Ln_Typ	Line Type

S_HWM - Point Z Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
HWM_ID	Long	-	-	-	R	-	Primary Key
Wtnss_ID	Long	-	-	-	R	-	Foreign key to L_HWMWtns table.
StrmLineID	Long	-	-	-	R	-	Foreign key to L_Wtr_Nm. Surface water feature name.
Comments	Text	254	-	-	A	-	General comments or notes.
Elev	Double	-	8	2	R	-	Elevation of water mark.
EventDt	Date	-	-	-	R	-	Date of the storm.
Freq_LID	Short	-	-	-	R	D_Frequency	Frequency of the storm event.
HWMNm	Text	50	-	-	R	-	Name of high water mark.
IntrviewDt	Date	-	-	-	R	-	Date of interview with witness to high water mark.
Len_LID	Short	-	-	-	R	D_Length_Units	Length Units
LnTyp_LID	Short	-	-	-	R	D_HWLnTp	HWM type
Location	Text	254	-	-	R	-	Location of the high water mark.
Source_Cit	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)
StormNm	Text	50	-	-	A	-	Name of storm.
SurvPrmt	Short	-	-	-	R	D_Boolean_YN	Do the surveyors have permission to survey? Yes/No.

S_HydraBFE - Polyline Z Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
BFE_LN_ID	Long	-	-	-	R	-	Primary Key
ELEV	Double	-	13	2	R	-	The rounded, whole foot Base Flood Elevation
LEN_LID	Short	-	-	-	R	D_Length_Units	Length Unit
V_DATM_LID	Short	-	-	-	R	D_V_Datum	Vertical datum
HydraID	Long	-	-	-	R	-	Foreign key to L_Hydramodel table.
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_HydraCrossSection - Polyline Z M Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
XsectID	Long	-	-	-	R	-	Primary Key
RefPtID	Long	-	-	-	R	-	A foreign key to the S_RefPoint.
STREAM_STN	Double	-	12	2	R	-	Distance from the reference point along the stream.
StrmLineID	Long	-	-	-	R	-	A foreign key to the L_Wtr_Nm table.
LEN_LID	Short	-	-	-	R	D_Length_Units	Length Units
V_DATM_LID	Short	-	-	-	R	D_V_Datum	Vertical Datum
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)
BED_ELEV	Double	-	8	2	R	-	Lowest stream bed elevation, from profile.
XsName	Text	100	-	-	R	-	Unique alpha-numeric name.
DataType	Short	-	-	-	R	D_DatTyp	Cross section type (Top of Road or Natural)
CenterStat	Double	-	9	2	R	-	The cross section station used in the model

S_HydraFlowPath - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
PathId	Long	-	-	-	R	-	Primary Key
StrmLineID	Long	-	-	-	R	-	Foreign key to L_Wtr_Nm table.
Water_LID	Short	-	-	-	R	D_Water_Typ	Surface Water Feture Type
PathName	Text	254	-	-	R	-	Unique alphanumeric identifier (i.e. CC-1).
PathType	Text	15	-	-	R	-	Stream, Structure, Pipe, Simple Channel.
InvenID	Long	-	-	-	A	-	Foreign key to an inventory table (only used for non-stream paths)
UpNodeID	Long	-	-	-	R	-	Foreign key to S_HydraJunction table.
DownNodeID	Long	-	-	-	R	-	Foreign key to S_HydraJunction table.
DsStation	Double	-	12	2	R	-	Distance measured from a prominent location
UsStation	Double	-	12	2	R	-	Distance measured from a prominent location
DsInvert	Double	-	8	2	A	-	Downstream thalweg elevation.
UsInvert	Double	-	8	2	A	-	Upstream thalweg elevation.
TopoOffset	Float	-	4	1	A	-	difference between true thalweg and the lowest profile elevation
Len_LID	Short	-	-	-	R	D_Length_Units	Length Units
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_HydraJunction - Point Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
JunctionId	Long	-	-	-	R	-	Primary Key
JunctName	Text	50	-	-	R	-	Unique alphanumeric identifier (i.e. A-201).
JunctType	Text	50	-	-	R	-	Transition, Manhole, Curb Inlet, Pipe Junction, etc.
InvenID	Long	-	-	-	A	-	Foreign key to an inventory table.
Invert	Double	-	8	2	A	-	Lowest elevation at junction
LEN_LID	Short	-	-	-	A	D_Length_Units	Length Units
V_DATM_LID	Short	-	-	-	A	D_V_Datum	Vertical Datum
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_HydraMapping - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
MapID	Long	-	-	-	R	-	Primary Key
StrmLineID	Long	-	-	-	R	-	Foreign key to L_Wtr_Nm table.
EventID	Long	-	-	-	R	-	Foreign key to L_HydraEvent table.
HydraID	Long	-	-	-	R	-	Foreign key to L_HydraModel table.
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_HydraNvalue - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
NvalueID	Long	-	-	-	R	-	Primary Key
Nvalue	Float	-	5	3	R	-	Manning's n-value. Usually a number between 0.01 and 0.20.
LandCover	Text	50	-	-	R	-	A brief description of the land cover
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_HydroBasin - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
BasinId	Long	-	-	-	R	-	Primary Key
BasinName	Text	100	-	-	R	-	An alpha-numeric name. Must be unique across a watershed.
Watershed	Text	100	-	-	R	-	Watershed name (multiple basins within each watershed)
StrmLineID	Long	-	-	-	R	-	A reference to L_Wtr_Nm table.
NodeID	Long	-	-	-	R	-	A foreign key to the S_HydroNode table.
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_HydroGage - Point Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
GageID	Long	-	-	-	R	-	Primary Key
GageName	Text	100	-	-	R	-	An alpha-numeric name.
GageDesc	Text	254	-	-	R	-	Information describing the location of the gage
Gage_LID	Short	-	-	-	R	D_Gage	Gage Type
Gage_ID	Text	25	-	-	R	-	Gage Identification. Assigned by the agency maintaining the gage
Agency	Text	150	-	-	R	-	Agency. Name of agency maintaining the gage.
Rec_Intvl	Text	11	-	-	R	-	Recording Interval. Recording interval for the gage.
Time_LID	Short	-	-	-	R	D_Time_Units	Time Units
Start_PD	Date	-	-	-	R	-	Start Period. (used in the gage analysis)
End_PD	Date	-	-	-	R	-	End Period. (used in the gage analysis)
TimeFname	Text	254	-	-	A	-	File name of database file with time series data
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_HydroImpervious - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
ImpID	Long	-	-	-	R	-	Primary Key
ImpervPerc	Double	-	6	2	R	-	Percent of impervious areas in the polygon.
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_HydroLandUse - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
LUID	Long	-	-	-	R	-	Primary Key
LUType	Text	50	-	-	R	-	Alpha-numeric name or abbreviation used to ID this land use type
LUDesc	Text	100	-	-	A	-	Detailed description of this land use.
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_HydroLink - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
LinkID	Long	-	-	-	R	-	Primary Key
StrmLineID	Long	-	-	-	R	-	A foreign key to the L_Wtr_Nm table.
LinkName	Text	254	-	-	A	-	An optional unique identification string for each reach.
UpNodeID	Long	-	-	-	A	-	A foreign key to the S_HydroNode table (upstream node)
DownNodeID	Long	-	-	-	A	-	A foreign key to the S_HydroNode table (downstream node)
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_HydroNode - Point Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
NodeID	Long	-	-	-	R	-	Primary Key
NodeName	Text	254	-	-	R	-	Description of the location.
IsPourPt	Short	-	-	-	R	D_Boolean_TF	Nodes can be either basin outlets/pour points or confluences.
StrmLineID	Long	-	-	-	R	-	Foreign key to L_Wtr_Nm. Surface water feature name.
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_HydroSoil - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
SoilID	Long	-	-	-	R	-	Primary Key
SoilType	Text	20	-	-	R	-	Soil Type (dependent on classification system utilized).
SoilAbbrev	Text	20	-	-	A	-	Abbreviation (i.e. Ch, Wg, Chcr).
SoilDesc	Text	100	-	-	A	-	Example: Watauga Silty Clay Loam.
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_HydroTC - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
TCID	Long	-	-	-	R	-	Primary Key
BasinID	Long	-	-	-	R	-	A foreign key to the S_HydroBasin table.
TC	Double	-	6	3	R	-	Time of concentration (time is by segment, not total for a basin).
Time_LID	Short	-	-	-	R	D_Time_Units	Time Units
Regime	Text	10	-	-	R	-	Flow regime (i.e. Channel, Swale, Lake, Overland, Pipe, etc.).
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Island - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
IslandID	Long	-	-	-	R	-	Primary Key
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Label_Ld - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
LEADER_ID	Long	-	-	-	R	-	Primary Key
LABEL_LID	Short	-	-	-	R	D_Label_Typ	Label Type

S_Label_Pt - Point Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
LABEL_ID	Long	-	-	-	R	-	Primary Key
LABEL	Text	254	-	-	R	-	Label for map feature.
LABEL_LID	Short	-	-	-	R	D_Label_Typ	Label Type
DEGREES	Float	-	0	0	R	-	The degrees of text rotation

S_LOMR - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
LOMR_ID	Long	-	-	-	R	-	Primary Key
EFF_DATE	Date	-	-	-	R	-	Effective Date. Effective Date of the LOMR.
CASE_NO	Text	13	-	-	R	-	Case number of the LOMR that is assigned by FEMA.
StrmLineID	Long	-	-	-	R	-	References OBJECTID of Hydra_StreamCenter
SCALE_LID	Short	-	-	-	R	D_Scale	Map Scale.
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)
STATUS	Short	-	-	-	R	D_LOMC_Status	Status of the LOMR.

S_MT1_LOMC - Point Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
LOMC_ID	Long	-	-	-	R	-	Primary Key
CASE_NO	Text	13	-	-	R	-	Case number assigned by FEMA to the LOMC.
EFF_DATE	Date	-	-	-	R	-	Effective Date of the LOMA.
FIRM_PAN	Long	-	-	-	R	-	FIRM panel number that the LOMA is on.
LOMC_STAT	Short	-	-	-	R	D_LOMC_Status	Status of the LOMC.

S_NoData - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
NoDataID	Long	-	-	-	R	-	Primary Key
Elev	Double	-	10	3	A	-	Elevation to use other than -9999.
LEN_LID	Short	-	-	-	A	D_Length_Units	Length Units
V_DATM_LID	Short	-	-	-	A	D_V_Datum	Vertical Datum
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Ovrbnkln - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
OVRBNK_ID	Long	-	-	-	R	-	Primary Key
StrmLineID	Long	-	-	-	R	-	A foreign key to L_Wtr_Nm table.
OBNK_SIDE	Text	1	-	-	R	-	L or R, indicates Left or Right.
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Perimeter - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
PerimID	Long	-	-	-	R	-	Primary Key
Priority	Short	-	-	-	R	-	A value from 1 to X where 1 is highest priority. No duplicates.
Descript	Text	50	-	-	R	-	Unique descriptive name of a dataset
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Perm_Bmk - Point Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
BM_ID	Long	-	-	-	R	-	Primary Key
PID	Text	11	-	-	R	-	Permanent Identifier. (NGS assigned or community assigned)
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_PFD_Ln - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
PFD_ID	Long	-	-	-	R	-	Primary Key
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Photo - Point Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
Photo_ID	Long	-	-	-	R	-	Primary Key
Azimuth	Double	-	6	2	A	-	Horizontal angle of the bearing for the photo.
Comments	Text	254	-	-	A	-	General comments or notes.
FileNm	Text	254	-	-	R	-	Name of the photo file.
Location	Text	254	-	-	R	-	description of the geographic location where the picture was taken
PhotoDt	Date	-	-	-	R	-	The date that the picture was taken.
Source_Cit	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)
Subject	Text	50	-	-	R	-	Description of feature or view.
SXS_ID	Long	-	-	-	R	-	Foreign key to S_SXS.
HWM_ID	Long	-	-	-	R	-	Foreign key to Hydra_HWM.
ApxStr_ID	Long	-	-	-	R	-	Foreign key to S_ApxStr.
Struc_ID	Long	-	-	-	R	-	Foreign key to S_Struc.

S_PLSS_Ar - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
PLSS_AR_ID	Long	-	-	-	R	-	Primary Key
RANGE	Text	8	-	-	A	-	Range Number.
TWP	Text	8	-	-	A	-	Township.
SECT_NO	Text	4	-	-	R	-	Section.
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_PLSS_Ln - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
PLSS_LN_ID	Long	-	-	-	R	-	Primary Key
LN_LID	Short	-	-	-	R	D_Ln_Typ	Line Type
E_RANGE	Text	8	-	-	A	-	East Range Number.
W_RANGE	Text	8	-	-	A	-	West Range Number.
N_TWP	Text	8	-	-	A	-	North Township.
S_TWP	Text	8	-	-	A	-	South Township.
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Pol_Ar - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
POL_AR_ID	Long	-	-	-	R	-	Primary Key
POL_NAME1	Text	50	-	-	R	-	Political Area Name 1.
POL_NAME2	Text	50	-	-	R	-	Political Area Name 2.
CO_FIPS	Text	3	-	-	R	-	County FIPS Code.
ST_FIPS	Text	2	-	-	R	-	State FIPS.
COMM_NO	Text	4	-	-	R	-	Community Number.
CID	Text	6	-	-	R	-	Community Identification Number.
ANI_TF	Short	-	-	-	R	D_Boolean_TF	Area Not Included in FIRM?
REPOS_ADR1	Text	50	-	-	R	-	First line of the mailing or street address for the map repository.
REPOS_ADR2	Text	50	-	-	A	-	Second line of the mailing or street address for the map repository
REPOS_ADR3	Text	50	-	-	A	-	Third line of the mailing or street address for the map repository.
REPOS_CITY	Text	50	-	-	R	-	City portion of the mailing or street address for the map repository
REPOS_ST	Text	50	-	-	R	-	State portion of the address for the map repository.
REPOS_ZIP	Text	9	-	-	R	-	ZIP Code portion of the address for the map repository.
IN_ID_DAT	Date	-	-	-	R	-	Initial identification date for the community
IN_NFIP_DT	Date	-	-	-	R	-	Initial date of the first NFIP map published for this community.
IN_FRM_DAT	Date	-	-	-	R	-	Initial date FIRM was created.
RECENT_DAT	Date	-	-	-	A	-	Most recent panel date.

S_Pol_Ln - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
POL_LN_ID	Long	-	-	-	R	-	Primary Key
LN_TYP	Short	-	-	-	R	D_Ln_Typ	Line Type
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Quad_Index - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
QUAD_ID	Long	-	-	-	R	-	Primary Key
QUAD_NO	Text	8	-	-	R	-	Quad Number (eight-digit USGS alphanumeric quadrangle)
QUAD_NM	Text	50	-	-	R	-	Quad Name. (assigned by USGS)
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_RefPoint - Point Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
RefPtID	Long	-	-	-	R	-	Primary Key
Start_Desc	Text	254	-	-	R	-	Description of the location of the station starting point.
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Shore_Ln - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
SHR_LN_ID	Long	-	-	-	R	-	Primary Key
SHRTYP_LID	Short	-	-	-	R	D_Shr_Typ	Shoreline Type
V_DATM_LID	Short	-	-	-	R	D_V_Datum	Vertical Datum
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_SinkBreach - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
BreachID	Long	-	-	-	R	-	Primary Key
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_StreamCntrLine - Polyline Z M Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
StrmLineID	Long	-	-	-	R	-	Primary Key
WATER_LID	Short	-	-	-	R	D_Water_Typ	Surface Water Feture Type
WTR_NM	Text	100	-	-	R	-	Name of the reach (multiple features may have same WTR_NM)
SegName	Text	254	-	-	A	-	An optional unique identification string for each reach.
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)
StdyDetail	Short	-	-	-	R	D_StudyDetail	Level of detail of flood hazard study

S_StreamsDEM - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
StreamID	Long	-	-	-	R	-	Primary Key
InvAdjust	Double	-	10	3	A	-	Elevation offset of line.
LEN_LID	Short	-	-	-	A	D_Length_Units	Length Units
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Struc - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
Struc_ID	Long	-	-	-	R	-	Primary Key
CLEasting	Double	-	12	2	A	-	Easting or X-coordinate of centerline station.
CLNorthing	Double	-	12	2	A	-	Northing or Y-coordinate of centerline station.
CLStn	Double	-	2	0	A	-	Cross section station,
Comments	Text	254	-	-	A	-	General comments or notes.
DSInvert	Double	-	8	2	A	-	Elevation of the lowest point in stream
Len_LID	Short	-	-	-	R	D_Length_Units	Length Units
Lngth	Double	-	8	2	R	-	Distance from beginning of structure to end.
MtlBed_LID	Short	-	-	-	A	D_MtlTyp	Bed material type
MtlFil_LID	Short	-	-	-	A	D_MtlTyp	Fill material type
Orient	Text	1	-	-	A	-	Direction in which survey shots were taken (D or U)
RailAvgHt	Double	-	8	2	A	-	Average rail height.
RoadNm	Text	254	-	-	R	-	Road name or location of structure.
Skew	Double	-	8	4	A	-	Angle of structure, if not perpendicular to stream.
Source_Cit	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)
StreamStn	Double	-	12	2	A	-	Distance along stream from a user-defined reference point
Struct_LID	Short	-	-	-	R	D_Struct_Typ	Structure Type
Struct_Nm	Text	50	-	-	R	-	Field name of the structure.
SurveyDt	Date	-	-	-	R	-	Date and time of survey
SurveyFile	Text	254	-	-	R	-	Name of the survey text file.
TBM_ID	Long	-	-	-	R	-	TBM_ID of benchmark provides link to spatial file S_TBM.
USInvert	Double	-	8	2	A	-	Elevation of the lowest point in stream
Wdth	Double	-	8	2	R	-	hydraulic distance from one edge of structure to the other
StrmLineID	Long	-	-	-	R	-	Foreign key to L_Wtr_Nm. Surface water feature name.

S_SXS - Polyline Z M Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
SXS_ID	Long	-	-	-	R	-	Primary Key
Descript	Text	100	-	-	R	-	Description of surveyed cross section shot or point.
Source_Cit	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)
CLEasting	Double	-	12	2	R	-	X-coordinate at stream crossing.
CLNorthing	Double	-	12	2	R	-	Y-coordinate at stream crossing.
CLStn	Double	-	8	2	R	-	Cross section station at intersection of stream centerline.
Comments	Text	254	-	-	A	-	General comments or notes.
DatTyp_LID	Short	-	-	-	R	D_DatTyp	Cross section or data type
Invert	Double	-	8	2	R	-	Lowest elevation in cross section.
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
Location	Text	254	-	-	R	-	Description of location.
Orient	Text	1	-	-	R	-	Direction in which survey shots were taken. (D or U)
StreamStn	Double	-	12	2	R	-	Distance along stream.
Struc_ID	Long	-	-	-	A	-	Foreign key to S_Struc.
SurveyDt	Date	-	-	-	R	-	Date and time of survey.
StrmLineID	Long	-	-	-	R	-	Foreign key to L_Wtr_Nm. Surface water feature name.
XSNm	Text	65	-	-	R	-	Cross Section Name on FIRM
SurveyFile	Text	254	-	-	A	-	Name of the survey text file.
TBM_ID	Long	-	-	-	R	-	Foreign key to S_TBM. Elevation reference point of cross section.

S_TBM - Point Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
TBM_ID	Long	-	-	-	R	-	Primary Key
Descript	Text	254	-	-	R	-	Description of directions to location Temporary Benchmark.
Elev	Double	-	8	2	R	-	Elevation of Temporary Benchmark.
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
Owner	Text	50	-	-	R	-	Agency or municipality owns or maintains the monument.
Source_Cit	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)
SurveyDt	Date	-	-	-	R	-	Date the Temporary Benchmark was surveyed.
TBMNm	Text	50	-	-	R	-	Temporary Benchmark Name on FIRM

S_TileIndex - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
GridID	Text	20	-	-	R	-	Primary Key
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Trnsport_Ln - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
TRANS_ID	Long	-	-	-	R	-	Primary Key
TRANS_LID	Short	-	-	-	R	D_Trans_Typ	Transportation Line Type
RD_S_LID	Short	-	-	-	R	D_Rd_Status	Road Status
PREFIX	Text	50	-	-	A	-	Prefix of the Feature Name.
FEAT_NM1	Text	100	-	-	R	-	Feature Name 1
NM_LID	Short	-	-	-	R	D_Nm_Typ	Name Type
SUFFIX	Text	50	-	-	A	-	Suffix of the Feature Name.
FEAT_NM2	Text	100	-	-	A	-	Feature Name 2
FEAT_NM3	Text	100	-	-	A	-	Feature Name 3
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_VoidArea - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
VoidID	Long	-	-	-	R	-	Primary Key
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Wtr_Ar - Polygon Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
WTR_AR_ID	Long	-	-	-	R	-	Primary Key
WATER_LID	Short	-	-	-	R	D_Water_Typ	Surface Water Feature Type
WTR_NM	Text	100	-	-	R	-	Surface Water Feature Name on FIRM
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_Wtr_Ln - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
WTR_LN_ID	Long	-	-	-	R	-	Primary Key
WATER_LID	Short	-	-	-	R	D_Water_Typ	Surface Water Feature Type
WTR_NM	Text	100	-	-	R	-	Surface Water Feature Name on FIRM
CHAN_LID	Short	-	-	-	R	D_Chan_Rep	Channel Representation Type
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)

S_XS - Polyline Feature Class

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Shape	Geometry	-	-	-	R	-	[Feature geometries]
XS_LN_ID	Long	-	-	-	R	-	Primary Key
XS_LTR	Text	12	-	-	A	-	Cross-Section Letter on FIRM
RefPtID	Long	-	-	-	R	-	Start Identification.
STREAM_STN	Text	12	-	-	R	-	Stream Station.
XS_LN_TYP	Short	-	-	-	R	D_XS_Ln_TYP	Cross-Section Line Type.
StrmLineID	Long	-	-	-	R	-	Surface Water Feature
WSEL_REG	Double	-	8	2	R	-	Regulatory Water-Surface Elevation for the 1-Percent Flood Event.
LEN_LID	Short	-	-	-	R	D_Length_Units	Length Unit
V_DATM_LID	Short	-	-	-	R	D_V_Datum	Vertical Datum
SOURCE_CIT	Text	11	-	-	R	-	Source Citation (Abbreviation used in the metadata file)
BED_ELEV	Double	-	8	2	R	-	Streambed Elevation
TOP_WIDTH	Double	-	8	2	R	-	Top Width.
XS_AREA	Double	-	8	2	R	-	Cross Section Area.
AREA_LID	Short	-	-	-	R	D_Area_Units	Area Unit
VELOCITY	Double	-	8	2	R	-	Mean Velocity.
VEL_LID	Short	-	-	-	R	D_Velocity_Unit	Velocity Lookup

L_ApxBrdg - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
ApxBrdg_ID	Long	-	-	-	R	-	Primary Key
ApxStr_ID	Long	-	-	-	R	-	Foreign Key to S_ApxStr.
DeckThick	Double	-	8	2	R	-	Measurement from top of road to bottom of bridge.
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
NumPiers	Short	-	-	-	R	-	Number of piers.
PierWd	Double	-	8	2	R	-	Average width or span of piers, perpendicular to the streamflow.
ToeWd	Double	-	8	2	R	-	Width of a structure, measured between the abutments.
TopWd	Double	-	8	2	R	-	Width of structure, measured between outermost low chords.

L_ApxCul - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
ApxCul_ID	Long	-	-	-	R	-	Primary Key
ApxStr_ID	Long	-	-	-	R	-	Foreign Key to S_ApxStr.
ShpTyp_LID	Short	-	-	-	R	D_ShpTyp	Culvert shape type
CLStn	Double	-	8	2	R	-	Cross section station, in profile view
Invert	Double	-	8	2	R	-	Elevation at bottom of upstream pipe opening.
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
Rise	Double	-	8	2	R	-	Height or diameter of pipe.
Span	Double	-	8	2	R	-	Width or span of pipe.

L_ApxDam - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
ApxDam_ID	Long	-	-	-	R	-	Primary Key
ApxStr_ID	Long	-	-	-	R	-	Foreign Key to S_ApxStr.
Area_LID	Short	-	-	-	R	D_Area_Units	Units of area measure.
DamTopElv	Double	-	8	2	R	-	Elevation at top of dam.
DamTyp_LID	Short	-	-	-	R	D_DamTyp	Dam type
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
MtlTyp_LID	Short	-	-	-	R	D_MtlTyp	Material type
NormalArea	Double	-	10	2	R	-	Area of pool at normal water surface elevation.

L_ApxRsr - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
ApxRsr_ID	Long	-	-	-	R	-	Primary Key
ApxDam_ID	Long	-	-	-	R	-	Foreign Key to L_ApxDam.
ExPpRise	Double	-	8	2	R	-	Diameter or height of the exit pipe.
ExPpLn	Double	-	8	2	R	-	Length of the exit pipe.
ExPpTopElv	Double	-	8	2	R	-	Elevation at the top of the exit pipe.
ExPpWd	Double	-	8	2	R	-	Width of the exit pipe.
ExPShpT_ID	Short	-	-	-	R	D_ShpTyp	Exit pipe shape type
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
RsrHlCnt	Short	-	-	-	R	-	Number of riser holes.
RsrHlSp_ID	Short	-	-	-	R	D_ShpTyp	Riser hole shape type
RsrHlLn	Double	-	8	2	R	-	Length or diameter of riser holes.
RsrHlSpc	Double	-	8	2	R	-	Spacing between riser holes.
RsrHlWd	Double	-	8	2	R	-	Width of riser holes.
RsrHt	Double	-	8	2	R	-	Height of riser.
RsrLn	Double	-	8	2	R	-	Length or diameter of riser top opening.
RsrShpT_ID	Short	-	-	-	R	D_ShpTyp	Riser shape type
RsrTopElv	Double	-	8	2	R	-	Elevation at the top of the riser.
RsrWd	Double	-	8	2	R	-	Width of riser.
TrTopElv	Double	-	8	2	R	-	Elevation at the top of trashrack.
TrLn	Double	-	8	2	R	-	Length of the trashrack.
TrWd	Double	-	8	2	R	-	Width of the trashrack.

L_ApxSwy - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
ApxSWy_ID	Long	-	-	-	R	-	Primary Key
ApxDam_ID	Long	-	-	-	R	-	Foreign Key to L_ ApxDam.
BotWd	Double	-	8	2	R	-	Width at bottom of spillway.
Height	Double	-	8	2	R	-	Height of spillway.
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
TopElv	Double	-	8	2	R	-	Elevation at top of spillway.
TopWd	Double	-	8	2	R	-	Width at top of spillway.

L_Brdg - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Brdg_ID	Long	-	-	-	R	-	Primary Key
Struc_ID	Long	-	-	-	R	-	Foreign Key to S_Struc.
AbtTyp_LID	Short	-	-	-	R	D_AbtTyp	Abutment type
DeckThick	Double	-	8	2	R	-	Measurement from top of road to bottom of bridge.
LAbtmntStn	Double	-	8	2	R	-	Left station of abutment, input from survey data (profile)
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
LFillStn	Double	-	8	2	R	-	Station of left toe of fill (referencing profile view of structure).
LSideSlope	Float	-	5	2	R	-	Slope of left fill station.
RAbtmntStn	Double	-	8	2	R	-	Right station of abutment, input from survey data (profile).
RFillStn	Double	-	8	2	R	-	Station of right toe of fill (referencing profile view of structure).
RSideSlope	Float	-	5	2	R	-	Slope of right fill station.

L_CulPp - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
CulPp_ID	Long	-	-	-	R	-	Primary Key
Struc_ID	Long	-	-	-	R	-	Foreign Key to S_Struc.
CLStn	Double	-	12	2	R	-	Centerline station of pipe (referencing profile view of structure).
DSInvert	Double	-	8	2	R	-	Elevation at bottom of downstream pipe opening.
InTyp_LID	Short	-	-	-	R	D_PpTyp	Type of inlet.
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
MtlTyp_LID	Short	-	-	-	R	D_MtlTyp	Pipe material.
OutTyp_LID	Short	-	-	-	R	D_PpTyp	Type of outlet.
PipeLn	Double	-	8	2	R	-	Length of pipe.
Rise	Double	-	8	2	R	-	Height or diameter of pipe.
ShpTyp_LID	Short	-	-	-	R	D_ShpTyp	cross sectional shape of culvert.
USInvert	Double	-	8	2	R	-	Elevation at bottom of upstream pipe opening.
Wdth	Double	-	8	2	R	-	Width or span of pipe.

L_Cst_Model - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
CST_MDL_ID	Long	-	-	-	R	-	Primary Key
StrmLineID	Long	-	-	-	R	-	Surface Water Feature
SubInfoID	Long	-	-	-	R	-	Case Number Identification.
SURGE_LID	Short	-	-	-	R	D_Surge_Mdl	Hurricane Surge Model
SURGE_DATE	Date	-	-	-	R	-	Hurricane Surge Model Run Date.
SURGE_ZIP	Text	254	-	-	R	-	Filename/path of zip file of surge model documentation
SURGE_EFF	Date	-	-	-	R	-	Surge Effective Date. Effective date of the surge model.
WAVEHT_LID	Short	-	-	-	A	D_Wave_Mdl	Wave Height Model
WAVEHT_DT	Date	-	-	-	A	-	Wave Height Model Run Date.
RUNUP_LID	Short	-	-	-	A	D_Runup_Mdl	Runup Model
RUNUP_DATE	Date	-	-	-	A	-	Runup Model Run Date.
SETUP_METH	Text	100	-	-	A	-	Wave Setup Methodology.
SETUP_DATE	Date	-	-	-	A	-	Wave Setup Methodology Date.
PFD_TF	Short	-	-	-	R	D_Boolean_TF	Applied primary frontal dune criteria?
EROS_TF	Short	-	-	-	A	D_Boolean_TF	Has erosion treatment been applied in the coastal modeling?
WAVE_EFF	Date	-	-	-	A	-	Wave Effective Date.
WAVE_ZIP	Text	254	-	-	A	-	File name/path of zip file of wave height documentation.

L_Dam - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Dam_ID	Long	-	-	-	R	-	Primary Key
Struc_ID	Long	-	-	-	R	-	Foreign Key to S_Struc.
Area_LID	Short	-	-	-	R	D_Area_Units	Units of area measure.
DamHt	Double	-	8	2	R	-	Height of Dam.
DamTopElv	Double	-	8	2	R	-	Elevation at top of dam.
DamTyp_LID	Short	-	-	-	R	D_DamTyp	Dam type
EmbSlope	Float	-	5	2	R	-	Slope of embankment.
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
NormalArea	Double	-	10	2	R	-	Area of pool at normal water surface elevation.
NWSElv	Double	-	8	2	R	-	Normal water surface elevation (level pool elevation).
ValveEasting	Double	-	12	2	A	-	Easting or X-coordinate of drain valve.
ValveNorth	Double	-	12	2	A	-	Northing or Y-coordinate of drain valve.

L_HWMWtns - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Wtnss_ID	Long	-	-	-	R	-	Primary Key
Address	Text	254	-	-	R	-	Physical address of witness to high water mark.
Phone	Text	20	-	-	R	-	Telephone number of witness to high water mark.
ResLngth	Long	-	-	-	R	-	The length of time a witness has lived at a particular residence.
Time_LID	Short	-	-	-	R	D_Time_Units	Units of temporal measure.
WtnssNm	Text	60	-	-	R	-	Name of witness to high water mark.

L_HydraEvent - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
EventId	Long	-	-	-	R	-	Primary Key
Freq_LID	Short	-	-	-	R	D_Frequency	The return frequency of the event
Descript	Text	32	-	-	R	-	Brief description of flood event
IsFW	Short	-	-	-	R	D_Boolean_TF	Identifies a floodway simulation.

L_HydraFloodResult - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
ResultId	Long	-	-	-	R	-	Primary Key
HydraID	Long	-	-	-	R	-	Foreign Key to the L_HydraModel table.
XsectID	Long	-	-	-	R	-	Foreign Key to the S_HydraCrossSection spatial file.
EventId	Long	-	-	-	R	-	Foreign Key to the L_HydraEvent table.
WSEL_Model	Double	-	8	2	R	-	Modeled flood elevation.
WSEL_Reg	Double	-	8	2	R	-	Regulatory flood elevation that matches profile
Discharge	Double	-	9	1	R	-	Discharge.
DISCH_LID	Short	-	-	-	R	D_Discharge_Units	Discharge Units
TOP_WIDTH	Double	-	9	2	A	-	Floodway width, used in floodway data table.
XS_AREA	Double	-	10	2	A	-	Underwater cross section area used in floodway data table.
AREA_LID	Short	-	-	-	A	D_Area_Units	Area Units
VELOCITY	Double	-	8	2	A	-	Mean velocity, used in the floodway data table.
VEL_LID	Short	-	-	-	A	D_Velocity_Unit	Velocity Units
LEN_LID	Short	-	-	-	R	D_Length_Units	Length Units
V_DATM_LID	Short	-	-	-	R	D_V_Datum	Vertical Datum

L_HydraModel - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
HydraID	Long	-	-	-	R	-	Primary Key
Hydra_LID	Short	-	-	-	R	D_Hydra	Hydraulic Model
SubInfoID	Long	-	-	-	R	-	Foreign Key to L_Submittal_Info table.
Descript	Text	254	-	-	R	-	Model description.
ZipName	Text	254	-	-	R	-	File name of zipped hydraulic model
RptName	Text	254	-	-	R	-	File name of the FIS narrative report
WTR_NM	Text	100	-	-	R	-	References the WTR_NM field of the S_StreamCntrLine feature
IsNetwork	Short	-	-	-	R	D_Boolean_TF	Specifies whether this is a network or backwater model.

L_HydroCNResult - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
CNID	Long	-	-	-	R	-	Primary Key
BasinID	Long	-	-	-	R	-	Foreign Key to S_HydroBasin.
CN	Float	-	6	2	R	-	Calculated SCS curve number.
CNGroupID	Long	-	-	-	R	-	Foreign Key to the L_HydroCNLookup table.
Watershed	Text	100	-	-	A	-	References the Watershed field of associated S_HydroBasin

L_HydroCNLookup - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
CNLookupID	Long	-	-	-	R	-	Primary Key
CNGroupID	Long	-	-	-	R	-	Used to identify a set of Curve Number lookups.
SCSSoil	Text	2	-	-	R	-	SCS Hydrologic Soil Type (A, B, C, D).
LUType	Text	50	-	-	R	-	Land use name.
CN	Float	-	6	2	R	-	SCS curve number for this land use / soil combination.
AMC	Short	-	-	-	R	-	Antecedent moisture condition (1,2 or 3).
SCSLUType	Text	50	-	-	A	-	Example: Open Space - Fair condition.
Source	Text	254	-	-	R	-	SCS TR-55, etc.

L_HydroEquation - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
HydEqID	Long	-	-	-	R	-	Primary Key
Equation	Text	254	-	-	R	-	Textual depiction of equation (i.e. Q10 = 622*DA^0.75).
Freq_LID	Short	-	-	-	R	D_Frequency	Event Frequency
Descript	Text	50	-	-	R	-	Details about the equation (2000 NC Regression Equations).

L_HydroEvent - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
EventID	Long	-	-	-	R	-	Primary Key
Freq_LID	Short	-	-	-	R	D_Frequency	The return frequency of the event
Descript	Text	32	-	-	R	-	Brief description of flood event (i.e. 10-year or Hurricane Hugo).

L_HydroModel - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
HydroID	Long	-	-	-	R	-	Primary Key
Hydro_LID	Short	-	-	-	R	D_Hydro	Hydrologic Model
Descript	Text	254	-	-	R	-	Model description.
ZipName	Text	254	-	-	A	-	File name of zipped hydrologic model
Watershed	Text	100	-	-	R	-	References the Watershed field of associated S_HydroBasin
SubInfoID	Long	-	-	-	R	-	Foreign Key to L_Submittal_Info table.
RPTName	Text	254	-	-	R	-	File name of the design hydrology report
CNGroupID	Long	-	-	-	A	-	Foreign Key to L_HydroCNLookup table
IsNew	Short	-	-	-	R	D_Boolean_TF	new model or modification/reference of an existing model.

L_HydroNodeParam - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
NodeParID	Long	-	-	-	R	-	Primary Key
NodeID	Long	-	-	-	R	-	Foreign Key to S_HydroNode.
ParamID	Long	-	-	-	R	-	Foreign Key to L_HydroParam.
ParamValue	Double	-	16	6	R	-	Value for this parameter at this node.

L_HydroParam - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
ParamID	Long	-	-	-	R	-	Primary Key
ShortName	Text	50	-	-	R	-	Name of parameter. Used in regression equation.
Descript	Text	254	-	-	A	-	Details about this parameter.
UnitType	Short	-	-	-	R	D_Unit_Type	Type of unit.
UnitID	Short	-	-	-	R	-	Foreign Key to corresponding domain table.

L_HydroResult - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
ResultID	Long	-	-	-	R	-	Primary Key
HydroID	Long	-	-	-	R	-	A reference to L_HydroModel.
EventID	Long	-	-	-	R	-	A reference to L_HydroEvent
Discharge	Double	-	9	1	R	-	Calculated discharge.
Disch_LID	Long	-	-	-	R	D_Discharge_Units	Discharge Units
Cumulative	Short	-	-	-	R	D_Boolean_TF	subbasin discharge or a cumulative discharge.
HydEqID	Long	-	-	-	A	-	A reference to L_HydroEquation table.
NodeID	Long	-	-	-	R	-	A reference to S_HydroNode table.
BasinID	Long	-	-	-	A	-	A reference to S_HydroBasin table.

L_HydroStormCurve - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
CurveID	Long	-	-	-	R	-	Primary Key
StormID	Long	-	-	-	R	-	Storm Identification.
Duration	Double	-	10	3	R	-	Duration of precipitation event.
Time_LID	Short	-	-	-	R	D_Time_Units	Duration Unit
Depth	Float	-	5	2	A	-	Precipitation Depth.
Len_LID	Short	-	-	-	A	D_Length_Units	Precipitation Depth Unit
Intensity	Float	-	5	2	A	-	Rainfall intensity.
Vel_LID	Short	-	-	-	A	D_Velocity_Unit	Rainfall Intensity Unit
EventID	Long	-	-	-	A	-	Foreign Key to L_HydroEvent table.

L_HydroStormInfo - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
StormID	Long	-	-	-	R	-	Primary Key
Storm_LID	Short	-	-	-	R	D_Storms	Storm Type
Storm_Desc	Text	254	-	-	A	-	Storm Description. Brief text description/note for the storm.
BasinID	Long	-	-	-	R	-	Foreign Key to the S_HydroBasin table.

L_LChrd - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
LChrd_ID	Long	-	-	-	R	-	Primary Key
Brdg_ID	Long	-	-	-	R	-	Foreign Key to L_Brdg.
Easting	Double	-	12	2	R	-	X-coordinate.
Elev	Double	-	8	2	R	-	Feet above sea level.
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
Northing	Double	-	12	2	R	-	Y-coordinate.
Station	Double	-	8	2	R	-	Cross section station (referencing profile view of structure).

L_Levee - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Levee_ID	Long	-	-	-	R	-	Primary Key
Accredit	Text	50	-	-	R	-	Accreditation or verification
Area_LID	Short	-	-	-	R	D_Area_Units	Units of area measure
Bank	Text	1	-	-	R	-	Side of channel on which structure is located (L or R)
ClsTyp_ID	Short	-	-	-	R	D_ClsTyp	Closure type
FreeBoard	Double	-	8	2	R	-	Minimum freeboard of structure.
HasFailed	Short	-	-	-	R	D_Boolean_YN	Have failures occurred? Yes/No.
IsMaint	Short	-	-	-	R	D_Boolean_YN	Is there a FEMA-approved maintenance plan? Yes/No.
IsOpPlan	Short	-	-	-	R	D_Boolean_YN	Is there an approved operational plan? Yes/No.
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
LevTyp_LID	Short	-	-	-	R	D_LevTyp	Levee type
ProtectAr	Double	-	10	2	R	-	Area protected.
ProtectLU	Text	1	-	-	R	-	Area protected is primarily developed - D, or undeveloped - U.
PrtectFreq	Short	-	-	-	R	D_Frequency	Exceedence frequency structure designed to protect
SideSlope	Float	-	5	2	R	-	Average side slope.
Struc_ID	Long	-	-	-	R	-	Foreign Key to S_Struc.
TopElv	Double	-	8	2	R	-	Average top elevation of levee.

L_NHD_LinearEvent - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
StrmLineID	Long	-	-	-	R	-	References OBJECTID of Hydra_StreamCenter
NHD_Reach	Text	14	-	-	R	-	ReachCode of the NHD 24K reach covering the FEMAstream
F_Measure	Float	-	6	3	R	-	From Measure
T_Measure	Float	-	6	3	R	-	To Measure

L_Orfc - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Orfc_ID	Long	-	-	-	R	-	Primary Key
RsrBrl_ID	Long	-	-	-	R	-	Foreign Key to L_RsrBrl.
CLElv	Double	-	8	2	R	-	Elevation at center of orifice.
Diameter	Double	-	8	2	R	-	Diameter of orifice.
Height	Double	-	8	2	R	-	Height of orifice.
Wdth	Double	-	8	2	R	-	Width of orifice.
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
OrfcCnt	Short	-	-	-	R	-	Number of same size orifices at a given elevation.
ShpTyp_ID	Short	-	-	-	R	D_ShpTyp	Orifice shape type

L_OtlPp - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
OtlPp_ID	Long	-	-	-	R	-	Primary Key
RsrBrl_ID	Long	-	-	-	R	-	Foreign Key to L_RsrBrl.
CLStn	Double	-	12	2	R	-	Centerline station where outlet pope is located.
Diameter	Double	-	8	2	R	-	Diameter of outlet pipe.
DSInvert	Double	-	8	2	R	-	Elevation at downstream invert of outlet pipe.
Height	Double	-	8	2	R	-	Height of outlet pipe.
InTyp_LID	Short	-	-	-	R	D_PpTyp	Inlet type
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
Lngth	Double	-	8	2	R	-	Length of outlet pipe.
MtlTyp_LID	Short	-	-	-	R	D_MtlTyp	Pipe material type
OutTyp_LID	Short	-	-	-	R	D_PpTyp	Outlet type
ShpTyp_LID	Short	-	-	-	R	D_ShpTyp	Pipe shape type
USInvert	Double	-	8	2	R	-	Elevation at upstream invert of outlet pipe.
Wdth	Double	-	8	2	R	-	Width of outlet pipe.

L_Pan_Revis - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
REVIS_ID	Long	-	-	-	R	-	Primary Key
FIRM_PAN	Long	-	-	-	R	-	FIRM Panel Number.
REVIS_DATE	Date	-	-	-	R	-	Revision Date.
REVIS_NOTE	Text	254	-	-	R	-	Revision Note.

L_PerimFile - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
PerimID	Long	-	-	-	R	-	Foreign Key to S_Perrimeter spatial file
FileName	Text	254	-	-	R	-	File title, i.e. G04_3DL.shp
Folder	Text	50	-	-	R	-	Submittal folder, i.e. Source\3DL

L_Pier - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Pier_ID	Long	-	-	-	R	-	Primary Key
Brdg_ID	Long	-	-	-	R	-	Foreign Key to L_Brdg.
CLStn	Double	-	8	2	R	-	Station at centerline of pier (profile view of structure).
ColumnCnt	Short	-	-	-	R	-	Number of columns of piers occurring at one station.
Easting	Double	-	12	2	R	-	X-coordinate.
Northing	Double	-	12	2	R	-	Y-coordinate.
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
ShpTyp_LID	Short	-	-	-	R	D_ShpTyp	Pier shape type
Wdth	Double	-	8	2	R	-	Width or span of pier, perpendicular to the streamflow.

L_Pol_FHBM - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
FHBM_ID	Long	-	-	-	R	-	Primary Key
CID	Long	-	-	-	R	-	Community Identification Number
FHBM_DATE	Date	-	-	-	R	-	FHBM revision date.
FHBM_NOTE	Text	254	-	-	R	-	FHBM revision note (reason for the revision).

L_Rail - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Rail_ID	Long	-	-	-	R	-	Primary Key
Struc_ID	Long	-	-	-	R	-	Foreign Key to S_Struc.
CLStn	Double	-	8	2	R	-	Station at centerline of rail (referencing profile view of structure).
Easting	Double	-	12	2	R	-	X-coordinate.
Elev	Double	-	8	2	R	-	Elevation at top of rail.
Height	Double	-	8	2	R	-	Height of rail.
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
Northing	Double	-	12	2	R	-	Y-coordinate.

L_RsrBrl - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
RsrBrl_ID	Long	-	-	-	R	-	Primary Key
Dam_ID	Long	-	-	-	R	-	Foreign Key to L_Dam.
BaseElv	Double	-	8	2	R	-	Elevation at the bottom of the riser barrel.
CLStn	Double	-	8	2	R	-	Station where riser barrel is located.
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
Lngth	Double	-	8	2	R	-	Length of the riser barrel.
MtlTyp_LID	Short	-	-	-	R	D_MtlTyp	Riser material type
ShpTyp_LID	Short	-	-	-	R	D_ShpTyp	Riser shape type
TopElv	Double	-	8	2	R	-	Elevation at the top of riser barrel.
TrHt	Double	-	8	2	R	-	Height of trashrack.
TrLn	Double	-	8	2	R	-	Length of trashrack.
TrTopElv	Double	-	8	2	R	-	Elevation at top of trashrack.
TrWd	Double	-	8	2	R	-	Width of trashrack.
Wdth	Double	-	9	2	R	-	Width of the riser barrel.

L_Sketch - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Sketch_ID	Long	-	-	-	R	-	Primary Key
Comments	Text	254	-	-	A	-	General comments or notes.
FileNm	Text	254	-	-	R	-	Name of the sketch file.
SketchDt	Date	-	-	-	R	-	Date the sketch was created.
SXS_ID	Long	-	-	-	R	-	Foreign Key to L_SXS.
HWM_ID	Long	-	-	-	R	-	Foreign Key to S_HWM.
Struc_ID	Long	-	-	-	R	-	Foreign Key to S_Struc.

L_Submittal_Info - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
SubInfoID	Long	-	-	-	R	-	Primary Key
CASE_NO	Text	12	-	-	R	-	FEMA Case Number for study.
CASE_DESC	Text	254	-	-	R	-	General description of the study.
EFF_DATE	Date	-	-	-	R	-	Effective date of the case.
STUDY_PRE	Text	20	-	-	A	-	Study prefix, i.e. City of.
STUDY_NM	Text	50	-	-	R	-	Study name.
STATE_NM	Short	-	-	-	R	D_State	State name.
CNTY_NM	Text	50	-	-	R	-	County name.
JURIS_TYP	Text	50	-	-	A	-	Political jurisdiction type.
LG_PAN_NO	Text	4	-	-	R	-	Largest panel number.
OPP_TF	Short	-	-	-	R	D_Boolean_TF	Only panel printed?
H_DATUM	Short	-	-	-	R	D_H_Datum	Horizontal datum.
V_DATM_LID	Short	-	-	-	R	D_V_Datum	Vertical datum
PROJECTION	Text	50	-	-	R	-	Map projection used for the hard copy FIRM publication.
PROJ_ZONE	Text	10	-	-	A	-	Projection zone.
CW_TF	Short	-	-	-	R	D_Boolean_TF	Countywide?
SW_TF	Short	-	-	-	R	D_Boolean_TF	Statewide?
CBRS_PHONE	Text	15	-	-	A	-	Coastal Barrier Resources System (CBRS) Phone number.
CBRS_REG	Text	1	-	-	A	-	CBRS Coordinator's region.
RTROFT_TF	Short	-	-	-	R	D_Boolean_TF	Retrofit?
META_NM	Text	50	-	-	R	-	Metadata file name. Must be stored in General folder.
STUDY_ZIP	Text	254	-	-	A	-	File name of the zipped file that contains the FIS report
SUBMIT_BY	Text	100	-	-	R	-	Company name of Mapping Partner submitting this dataset.
SUBMIT_CON	Text	100	-	-	R	-	Contact person for this submittal.
SUBMIT_PHO	Text	15	-	-	R	-	Phone number of Mapping Partner
Restricted	Short	-	-	-	R	D_Boolean_TF	Some data in this submittal can't be distributed freely.

L_SWy - Geodatabase Table

Field Name	Type	L	P	S	R/A	Domain	Description
OBJECTID	OID	-	-	-	R	-	[Autonumber]
Swy_ID	Long	-	-	-	R	-	Primary Key
Dam_ID	Long	-	-	-	R	-	Foreign Key to L_Dam.
BotWd	Double	-	8	2	R	-	Width at the bottom of spillway.
CLStn	Double	-	8	2	R	-	Centerline station of spillway.
CrestElv	Double	-	8	2	R	-	Elevation at crest of spillway.
Len_LID	Short	-	-	-	R	D_Length_Units	Units of linear measure.
SWyTyp_LID	Short	-	-	-	R	D_SwyTyp	Spillway type
TopElv	Double	-	8	2	R	-	Elevation at top of spillway.
TopWd	Double	-	8	2	R	-	Width at top of spillway.

D_AbtTyp - Coded Value Domain

Code	Description
1	Spill Through
2	Vertical Wall
3	Other
4	Unknown

D_Area_Units - Coded Value Domain

Code	Description
1000	ACRES
1010	HECTARES
1020	SQUARE FEET
1030	SQUARE METERS
1040	SQUARE YARDS
1050	SQUARE MILES

D_Boolean_TF - Coded Value Domain

Code	Description
0	FALSE
1	TRUE

D_Boolean_YN - Coded Value Domain

Code	Description
0	NO
1	YES

D_CBRS_Typ - Coded Value Domain

Code	Description
1000	COASTAL BARRIER RESOURCES SYSTEM
1010	OTHERWISE PROTECTED AREA

D_Chan_Rep - Coded Value Domain

Code	Description
1000	SINGLE
1010	DOUBLE

D_ClsTyp - Coded Value Domain

Code	Description
1	Combination
2	Floodgates
3	Other
4	Sandbags
5	Stop logs
6	None

D_DamTyp - Coded Value Domain

Code	Description
1	Concrete Arch
2	Concrete Gravity
3	Earthfill
4	Masonry
5	RCC
6	Rockfill
7	Rubber
8	Timber Crib
9	Other
10	Unknown

D_DatTyp - Coded Value Domain

Code	Description
1	Field
2	Top of Road

D_Dimensionless_Units - Coded Value Domain

Code	Description
0	[dimensionless]

D_Discharge_Units - Coded Value Domain

Code	Description
1000	CFS
1010	CMS
1020	GPD
1030	GPM

D_Eros_Meth - Coded Value Domain

Code	Description
1010	NOT APPLIED
1020	REMOVAL
1030	RETREAT

D_Floodway - Coded Value Domain

Code	Description
1000	FLOODWAY
1010	COLORADO RIVER
1020	FLOODWAY CONTAINED IN CHANNEL
1030	FLOWAGE EASEMENT BOUNDARY
1040	STATE ENCROACHMENT
1050	AREA OF SPECIAL CONSIDERATION

D_Frequency - Coded Value Domain

Code	Description
1001	0.2 PCT
1002	1 PCT
1003	2 PCT
1004	4 PCT
1005	10 PCT
1006	1 PCT LEVEE
1007	1 PCT LEVEE, RIGHT FAILED
1008	1 PCT LEVEE, LEFT FAILED
1009	1 PCT LEVEE, LEFT AND RIGHT FAILED
1010	1 PCT WITH FLOODWAY
1011	1 PCT WITHOUT FLOODWAY

D_Gage - Coded Value Domain

Code	Description
1000	FLOW
1010	FLOW / STAGE
1020	STAGE
1100	FIXED INTERVAL
1110	INSTANTANEOUS
1120	TIPPING
1200	WAVE HEIGHT
1210	WIND DIRECTION
1220	WIND SPEED
1230	WIND SPEED AND DIRECTION
1240	TIDE

D_H_Datum - Coded Value Domain

Code	Description
0	NAD27
1	NAD83

D_Hydra - Coded Value Domain

Code	Description
1000	ADVANCED ICPR 2.20 (OCTOBER 2000)
1001	DHM 21 (AUGUST 1987)
1002	FEQ 8.92 (1997)
1003	FEQUTL 4.68 (1997)
1004	FESWMS 2DH 1.1 (JUNE 1995)
1005	FLDWAV (NOVEMBER 1998)
1006	FLDWY (MAY 1989)
1007	FLO-2D V.2000.11 (DECEMBER 2000)
1008	GAGE ANALYSIS
1009	HCSWMM 4.31B (AUGUST 2000)
1010	HEC-2 4.6.2 (MAY 1991)
1011	HEC-RAS 2.2 (SEPTEMBER 1998)
1012	HEC-RAS 3.0.1
1013	HY8 4.1
1014	HY8 6.0
1015	MIKE 11 HD (JUNE 1999)
1016	PSUPRO
1017	QUICK-2 1.0
1018	QUICK-2 2.0
1019	SFD
1020	SHEET 2D 9 (JULY 2000)
1021	SWMM 4.30 (MAY 1994)
1022	SWMM 4.31 (JANUARY 1997)
1023	TABS-RMA2 V.4.3 (OCTOBER 1996)
1024	TABS-RMA4 V.4.5 (JULY 2000)
1025	UNET 4.0 (APRIL 2001)
1026	WSPGW 12.96 (OCTOBER 2000)
1027	WSPRO (JUNE 1988)

D_Hydro - Coded Value Domain

Code	Description
2000	AHYMO 97 (AUGUST 1997)
2001	CUHPF/PC (MAY 1996)
2002	DBRM 3.0 (1993)
2003	DR3M (OCTOBER 1993)
2004	FAN
2005	HEC-FFA 3.1
2006	HEC-1 4.0.1
2007	HEC-1 4.1
2008	HEC-HMS 1.1
2009	HEC-HMS 2.0
2010	HEC-HMS 2.0.3
2011	HEC-HMS 2.1.1
2012	HEC-HMS 2.1.2
2013	HEC-HMS 2.1.3
2014	HEC-IFH 1.03
2015	HEC-IFH 1.04
2016	HEC-IFH 2.0
2017	HEC-IFH 2.01
2018	HSPF 10.10
2019	HSPF 10.11
2020	HSPF 11.0
2021	HYMO
2022	MIKE 11 RR (JUNE 1999)
2023	MIKE 11 UHM (JUNE 1999)
2024	PEAKFQ 2.4 (APRIL 1998)
2025	PEAKFQ 2.5
2026	PEAKFQ 3.0
2027	PEAKFQ 4.0
2028	RATIONAL METHOD
2029	REGRESSION EQUATIONS
2030	SNYDER METHOD
2031	SWMM (RUNOFF) 4.30 (MAY 1994)
2032	SWMM (RUNOFF) 4.31 (JANUARY 1997)
2033	TR-20 (FEBRUARY 1992)
2034	TR-55 (JUNE 1986)

D_HWLnTp - Coded Value Domain

Code	Description
1	Mud
2	Debris
3	Other

D_Label_Typ - Coded Value Domain

Code	Description
1000	DOQ-TRANSPORTATION
1010	DOQ-WATER
1020	S_TRNSPORT_LN
1030	S_WTR_AR
1040	S_WTR_LN

D_Length_Units - Coded Value Domain

Code	Description
1000	CENTIMETERS
1010	FEET
1020	INCHES
1030	KILOMETERS
1040	METERS
1050	MILES
1060	MILLIMETERS

D_LevTyp - Coded Value Domain

Code	Description
1	Floodwall
2	Levee
3	Levee and floodwall
4	Ring levee
5	Road embankment
6	RR embankment
7	Other

D_Ln_Typ - Coded Value Domain

Code	Description
1010	AREA NOT INCLUDED
1020	CORPORATE
1021	EXTRATERRITORIAL JURISDICTION
1022	LEVEE IMPROVEMENT DISTRICT
1023	MUNICIPAL UTILITY DISTRICT
1024	UTILITY DISTRICT
1025	MISCELLANEOUS JURISDICTIONAL LAND
1026	MISCELLANEOUS PUBLIC LAND BOUNDARY
1030	COUNTY
1040	FOREST
1041	PARK
1042	RESERVATION
1050	INTERNATIONAL
1060	STATE
1070	URBAN GROWTH BOUNDARY
1080	MUNICIPAL URBAN DRAINAGE DISTRICT
2000	0.2 PCT ANNUAL CHANCE FLOOD HAZARD
2001	1 PCT ANNUAL CHANCE FLOOD HAZARD
2002	ZONE D
2030	APPARENT LIMIT
2031	LIMIT OF DETAILED STUDY
2032	LIMIT OF FLOODWAY
2033	LIMIT OF STUDY
2040	FLOODWAY
2050	FLOWAGE EASEMENT BOUNDARY
2051	STATE ENCROACHMENT LINE
2052	ZONE BREAK
3000	QUARTER SECTION
3010	RANGE
3020	TOWNSHIP
3030	SECTION
3040	MEANDER
4000	SOURCE BOUNDARY
9000	END OF SPATIAL EXTENT

D_LOMC_Status - Coded Value Domain

Code	Description
1	Revalidated
2	Superceded
3	Incorporated
4	Redetermined

D_Method - Coded Value Domain

Code	Description
1010	CUT FROM TOPO
1020	DIGITIZED FROM FIRM
1030	FIELD SURVEY

D_MtlTyp - Coded Value Domain

Code	Description
1	Gravel
2	Silt
3	Clay
4	Earthen
5	Concrete
6	Other
7	Unknown

D_Nm_Typ - Coded Value Domain

Code	Description
1000	ALLEY
1001	ARCADE
1002	AVENIDA
1003	AVENUE
1004	BOULEVARD
1005	BYPASS
1006	CALLE
1007	CAUSEWAY
1008	CENTER
1009	CIRCLE
1010	COUNTY HIGHWAY
1011	COURT
1012	COVE
1013	CRESCENT
1014	CROSSING
1015	DRIVE
1016	ESTE
1017	EXPRESSO
1018	EXPRESSWAY
1019	FREEWAY
1020	HIGHWAY
1021	INTERSTATE HIGHWAY
1022	LANE
1023	LOOP
1024	MOTORWAY
1025	NORTE
1026	OESTE
1027	PARKWAY
1028	PASEO
1029	PASS
1030	PATH
1031	PIKE
1032	PLACE
1033	PLAZA
1034	ROAD
1035	ROW
1036	RUE
1037	SQUARE
1038	STATE HIGHWAY
1039	STREET
1040	SUR
1041	TERRACE
1042	THROUGHWAY
1043	TRAFFICWAY
1044	TRAIL
1045	TURNPIKE
1046	WAY

D_Nodes - Coded Value Domain

Code	Description
1000	DIVERSION
1010	JUNCTION
1020	RESERVOIR
1030	STRUCTURE

D_Panel_Typ - Coded Value Domain

Code	Description
1000	COUNTYWIDE, PANEL PRINTED
1010	COUNTYWIDE, NOT PRINTED
1020	COMMUNITY BASED, PANEL PRINTED
1030	COMMUNITY BASED, NOT PRINTED
1040	UNMAPPED COMMUNITY

D_PpTyp - Coded Value Domain

Code	Description
1	Socket
2	Projecting from fill
3	Bell
4	Other
5	Unknown

D_Rd_Status - Coded Value Domain

Code	Description
1000	PAVED
1010	PROPOSED
1020	UNDER CONSTRUCTION
1030	UNIMPROVED

D_Runup_Mdl - Coded Value Domain

Code	Description
1010	ACES 1.07 (1992)
1020	CHAMP (1.0) (2001)
1030	EROSION (1998)
1040	GLWRM (1992)
1050	RUNUP 2.0 (1990)

D_Scale - Coded Value Domain

Code	Description
1000	6000
1010	12000
1020	24000

D_ShpTyp - Coded Value Domain

Code	Description
1	Circular
2	Box
3	Rectangular
4	Elliptical
5	Octagonal
6	Other
7	Trapezoidal
9	Unknown

D_Shr_Rough - Coded Value Domain

Code	Description
1001	VERY LOW
1002	LOW
1003	MODERATE
1004	HIGH
1005	VERY HIGH

D_Shr_Typ - Coded Value Domain

Code	Description
1001	ZERO FOOT CONTOUR FIELD SURVEY
1002	ZERO FOOT CONTOUR LIDAR/SHOALS

D_Storms - Coded Value Domain

Code	Description
1000	CHICAGO
1010	DDF
1020	HUFF
1030	IDF
1040	SANTA BARBARA
1050	SCS TYPE I
1060	SCS TYPE II
1070	SCS TYPE IIA
1080	SCS TYPE III
1090	TRIANGULAR
1100	UNIFORM

D_Struct_Typ - Coded Value Domain

Code	Description
1000	AQUEDUCT
1001	BRIDGE
1002	CANAL
1003	CHANNEL
1004	CHANNEL CONTAINS 0.2 PCT FLOOD EVENT
1005	CHANNEL CONTAINS 1 PCT FLOOD EVENT
1006	CONTROL STRUCTURE
1007	CULVERT
1008	CULVERT CONTAINS 0.2 PCT FLOOD EVENT
1009	CULVERT CONTAINS 1 PCT FLOOD EVENT
1010	DAM
1011	DIKE
1012	DOCK
1013	DROP STRUCTURE
1014	ENERGY DISSIPATER
1015	FISH LADDER
1016	FLOODWAY CONTAINED IN CHANNEL
1017	FLUME
1018	FOOTBRIDGE
1019	GATE
1020	JETTY
1021	LEVEE
1022	LOCK
1023	PENSTOCK
1024	PIER
1025	PUMP STATION
1026	SEAWALL
1027	SIDE WEIR STRUCTURE
1028	STORM SEWER
1029	UTILITY CROSSING
1030	WEIR
1031	WING WALL
1032	STRUCTURE CONTAINS 1 PCT FLOOD EVENT

D_Surge_Mdl - Coded Value Domain

Code	Description
1010	DYNLET
1020	FEMA SURGE (1988)
1030	FLOW2D (1975)
1040	MIKE 21 HD/NHD
1050	NEW ENGLAND TIDE PROFILE
1060	NORTHEASTER MODEL (1978)
1070	ODISTIM (1975)
1080	TABS RMA2 V.4.3 (OCTOBER 1996)
1090	USACE GREAT LAKES TIDE PROFILE (1998)

D_State - Coded Value Domain

Code	Description
1	ALABAMA
2	ALASKA
4	ARIZONA
5	ARKANSAS
6	CALIFORNIA
8	COLORADO
9	CONNECTICUT
10	DELAWARE
11	DISTRICT OF COLUMBIA
12	FLORIDA
13	GEORGIA
15	HAWAII
16	IDAHO
17	ILLINOIS
18	INDIANA
19	IOWA
20	KANSAS
21	KENTUCKY
22	LOUISIANA
23	MAINE
24	MARYLAND
25	MASSACHUSETTS
26	MICHIGAN
27	MINNESOTA
28	MISSISSIPPI
29	MISSOURI
30	MONTANA
31	NEBRASKA
32	NEVADA
33	NEW HAMPSHIRE
34	NEW JERSEY
35	NEW MEXICO

36	NEW YORK
37	NORTH CAROLINA
38	NORTH DAKOTA
39	OHIO
40	OKLAHOMA
41	OREGON
42	PENNSYLVANIA
44	RHODE ISLAND
45	SOUTH CAROLINA
46	SOUTH DAKOTA
47	TENNESSEE
48	TEXAS
49	UTAH
50	VERMONT
51	VIRGINIA
53	WASHINGTON
54	WEST VIRGINIA
55	WISCONSIN
56	WYOMING
60	AMERICAN SAMOA
66	GUAM
72	PUERTO RICO
78	VIRGIN ISLANDS

D_StudyDetail - Coded Value Domain

Code	Description
1	Approximate
2	Enhanced Approximate
3	Detail
4	Redelineation
5	Digital Conversion

D_SwyTyp - Coded Value Domain

Code	Description
1	Auxiliary/Emergency
2	Service/Principal
3	Other
4	Unknown

D_Temp_Units - Coded Value Domain

Code	Description
1	Degrees Celsius
2	Degrees Fahrenheit

D_Time_Units - Coded Value Domain

Code	Description
1000	DAYS
1010	HOURS
1020	MINUTES
1030	MONTHS
1040	SECONDS
1050	WEEKS
1060	YEARS

D_Trans_Typ - Coded Value Domain

Code	Description
1000	UNDEFINED ROAD
1001	PRIMARY ROAD
1002	SECONDARY ROAD
1003	TRAIL
1010	ROAD TUNNEL
1020	FORD
2000	UNDEFINED RAILROAD
2001	ACTIVE RAILROAD
2002	ABANDONED RAILROAD
2003	DISMANTLED RAILROAD
2010	RAILROAD TUNNEL
3000	AIRPORT
4000	FERRY

D_Unit_Type - Coded Value Domain

Code	Description
0	[dimensionless]
1	Area
2	Discharge
3	Length
4	Temperature
5	Time
6	Velocity
7	Volume

D_V_Datum - Coded Value Domain

Code	Description
1000	MSL
1010	NAVD88
1020	NGVD29

D_Velocity_Unit - Coded Value Domain

Code	Description
1000	CENTIMETERS / DAY
1010	CENTIMETERS / HOUR
1020	FEET / SECOND
1030	INCHES / DAY
1040	INCHES / HOUR
1050	METERS / SECOND
1060	MICROMETERS / SECOND
1070	MILLIMETERS / DAY
1080	MILLIMETERS / HOUR

D_Volume_Units - Coded Value Domain

Code	Description
1000	ACRE-FEET
1010	CUBIC FEET
1020	CUBIC METERS
1030	CUBIC YARDS
1040	GALLONS
1050	LITERS
1060	MILLION GALLONS

D_VZone - Coded Value Domain

Code	Description
1010	30 FOOT SPLASH ZONE BEHIND STRUCTURE
1020	PFD
1030	RUNUP EXTENT
1040	WHAFIS

D_Water_Typ - Coded Value Domain

Code	Description
1000	AREA OF COMPLEX CHANNELS
1001	ARTIFICIAL PATH
1002	BAY / INLET
1003	BAYOU
1004	BOG
1005	BYPASS / DIVERSION
1006	CANAL / DITCH
1007	CHANNEL
1008	CONCRETE / EARTHEN CHANNEL
1009	CONCRETE / EARTHEN DITCH
1010	CONCRETE CHANNEL
1011	CONCRETE DITCH
1012	CONNECTOR
1013	CREEK
1014	CREVASSE FIELD
1015	DETENTION POND
1016	EARTHEN CHANNEL
1017	EARTHEN DITCH
1018	ESTUARY
1019	FISH LADDER
1020	FLUME
1021	GULCH
1022	HATCHERY
1023	ICE MASS / GLACIER
1024	INTERMITTENT RIVER / STREAM
1025	LAKE / POND
1026	LOCK CHAMBER
1027	MUD POT
1028	NONEARTHEN SHORE
1029	OVERFLOW
1030	PERENNIAL RIVER / STREAM
1031	PLAYA
1032	PROFILE BASELINE
1033	RACE
1034	RESERVOIR
1035	RETENTION POND
1036	SAND PIT
1037	SEA / OCEAN
1038	SHORELINE / COASTLINE
1039	SPILLWAY
1040	STREAM / RIVER
1041	SUBMERGED STREAM
1042	SWAMP / MARSH
1043	TAILINGS POND
1044	UNDERPASS
1045	WASH

1046	WASTE WATER LAGOON / POND
1047	WATER SEPARATION LINE
1048	WATERFALL
1049	WATERWAY
1050	WETLANDS
1051	NAVIGABLE WATERWAY
1052	SOUND
1053	ISLAND
1054	CHANNEL CONTAINS 1 PCT FLOOD EVENT
1055	HYDROLOGIC LINK
1056	PROFILE BASELINE AND STREAM CENTERLINE
1057	STREAM CENTERLINE

D_Wave_Mdl - Coded Value Domain

Code	Description
1010	CHAMP 1.0 (2001)
1020	MIKE 21 (OSW)
1030	MIKE 21 (NSW)
1040	RCPWAVE (1986)
1050	WHAFIS 3.0 (1988)
1060	WHAFIS 3.0 GL (1993)

D_XS_Ln_TYP - Coded Value Domain

Code	Description
1	Lettered
2	Not Lettered

D_Zone - Coded Value Domain

Code	Description
1000	A
1001	AE
1002	AH
1003	AO
1004	AR
1005	1 PCT ANNUAL CHANCE FLOOD HAZARD CONTAINED IN CHANNEL
1006	1 PCT FUTURE CONDITIONS
1007	A99
1008	V
1009	VE
2000	0.2 PCT ANNUAL CHANCE FLOOD HAZARD
2001	0.2 PCT ANNUAL CHANCE FLOOD HAZARD CONTAINED IN CHANNEL
3000	AREA NOT INCLUDED
4000	D
4001	X PROTECTED BY LEVEE
4002	X
5000	OPEN WATER